

AIR FORCE QUALIFICATION TRAINING PACKAGE (AFQTP)



for
HVAC/REFRIGERATION
(3E1X1)

MODULE 21

AIR CONDITIONING & REFRIGERATION SYSTEMS

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Career Field Education and Training Plan (CFETP) references from 1 Apr 97 version.

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AIR FORCE QUALIFICATION TRAINING PACKAGES
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HVAC/REFRIGERATION
(3E1X1)

INTRODUCTION

Before starting this AFQTP, refer to and read the “Trainee/Trainer Guide” located on the AFCESA Web site <http://www.afcesa.af.mil/>

AFQTPs are mandatory and must be completed to fulfill task knowledge requirements on core and diamond tasks for upgrade training. *It is important for the trainer and trainee to understand* that an AFQTP **does not** replace hands-on training, nor will completion of an AFQTP meet the requirement for core task certification. AFQTPs will be used in conjunction with applicable technical references and hands-on training.

AFQTPs and Certification and Testing (CerTest) must be used as minimum upgrade requirements for Diamond tasks.

MANDATORY minimum upgrade requirements:

Core task:

AFQTP completion
Hands-on certification

Diamond task:

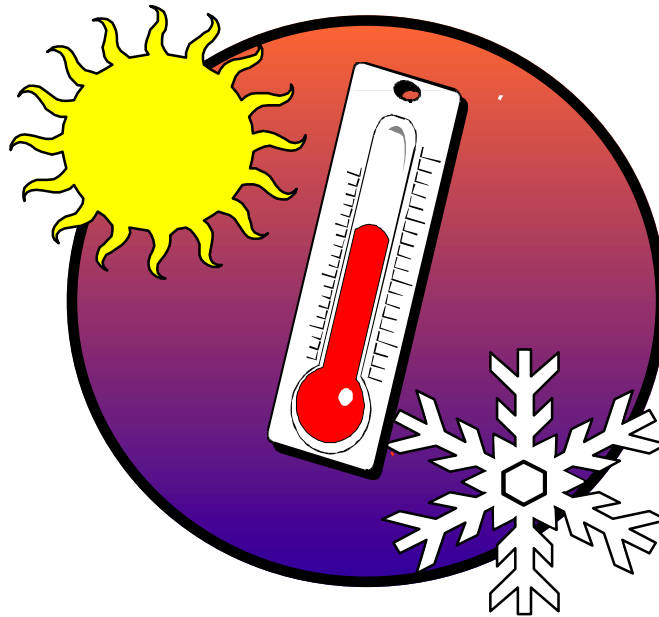
AFQTP completion
CerTest completion (80% minimum to pass)

Note: *Trainees will receive hands-on certification training for Diamond Tasks when equipment becomes available either at home station or at a TDY location.*

Put this package to use. Subject matter experts, under the direction and guidance of HQ AFCESA/CEOT, revised this AFQTP. If you have any recommendations for improving this document, please contact the HVAC/R Career Field Manager at the address below.

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PROCESS REFRIGERANTS IAW EPA AND AIR FORCE STANDARDS

MODULE 21

AFQTP UNIT 3

LOCATE REFRIGERANT LEAKS (21.3.1.)

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LOCATE REFRIGERANT LEAKS

Task Training Guide

STS Reference Number/Title:	21.3.1. Locate Refrigerant Leaks
Training References:	<ul style="list-style-type: none">• Modern Refrigeration & Air Conditioning; Trane Air Conditioning Manual
Prerequisites:	<ul style="list-style-type: none">• Possess as a minimum a, 3E131 AFSC.
Equipment/Tools Required:	<ul style="list-style-type: none">• Protective Personnel Equipment (PPE)• Standard HVAC/R Tool Bag• Manifold Gauge Assembly
Learning Objective:	<ul style="list-style-type: none">• Trainee should know the methods of locating leaks in a refrigerant system.
Samples of Behavior:	<ul style="list-style-type: none">• Trainee should know how to locate leak in a refrigerant system.
Notes:	
<ul style="list-style-type: none">• Any safety violation is an automatic failure.	

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LOCATE REFRIGERANT LEAKS

Background: Refrigeration systems must be absolutely gas tight for two reasons. First, any leakage will result in loss of the refrigerant charge. Second, leaks allow air and moisture to enter the system. Leaks can occur not only from joints or fittings not properly made at the time of the original installation, but from line breakage due to vibration, gasket failure, or other operating malfunctions. A recent study by a major user of commercial equipment revealed that of approximately 3,000 service calls made during a typical years operation, 1 out of 10 were required because of refrigerant leaks. Since leak detection is such a common service complaint, it is essential that the service specialist check the system carefully to insure that it is gas tight before charging with refrigerant.

The Environmental Protection Agency (EPA) has set some regulations when leaks must be repaired or the owner and possibly the technicians will be held responsible. For any appliance containing more than 50 pounds of refrigerant, the owner must keep a record of all refrigerant charged into that appliance.

For commercial and industrial process refrigeration systems, when the leak rate exceeds 35% of the system charge per year, it must be repaired. For any other appliance the leak rate is 15% before it has to be repaired. All leaks must be repaired within 30 days or the owner must develop a plan to scrap or retrofit the appliance with a safer refrigerant within 1 year.

Leak Indicators. If you suspect a leak on an appliance, manifold gage pressures abnormally low, and/or excessive superheat could be indicators. There are other things that will also indicate a low charge due to a leak. Remember, if an appliance is low on refrigerant, the only way that it can happen is by a leak somewhere in the appliance. Your problem is to find it, then repair it.

Looking for oil traces or residue also indicates the location of leaks. On open type compressors, Always check the shaft seal where the crankshaft comes through the compressor housing.

NOTE:

Schrader type valves should be inspected to insure the stem is not bent or leaking.

The failure of a system to hold a vacuum after being evacuated indicates that the system has a leak.

If a system refuses to hold a vacuum after it has been evacuated, the method of finding the leak will depend on the type of system. A low-pressure chiller should be pressurized for leak checking with controlled hot water where as high-pressure appliances nitrogen is used.

Pressurizing newly installed split systems or built-up systems with Hydro chlorofluorocarbons (HCFC) or Chlorofluorocarbons (CFC) refrigerants for leak checking are prohibited. Today, the law specifies that leak checking will be done using a pressurized inert gas that is environmentally safe such as nitrogen.

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Types of Leak Detectors:

- **Soap Solution.** The liquid bubble type leak indicator is a mixture of soap and water using sudsy type soap. Another popular solution is a soap bubble solution sold as a toy for the purpose of blowing bubbles. When using this type of leak indicator do not shake the soap solution bottle. It works far better when applied as a liquid. Swab a suspected leak with liquid soap or detergent, and bubbles will appear if a leak exists.

NOTE:

The bubble type method is not as easy to use as the electronic type leak detector, since it only locates large leaks, but it is an excellent method to check and pinpoint leaks.

- **Electronic.** These leak detectors measure the resistance of gas samples. The probe of this detector is passed around the suspected leak very slowly. It will get you in the general area of the leak. Most of the electronic type detectors give a visible and audible indication when sensing refrigerant vapor. These instruments will detect a leak at the rate of 1/2 oz. per year. Because of their extreme sensitivity, electronic detectors can only be used in a clean atmosphere not contaminated by refrigerant vapor, smoke, vapor from carbon tetrachloride, or other solvents, which may give a false reaction.

Depending on leak detector capabilities will determine what types of refrigerant it will detect. In checking an existing system, which has been in operation, it is usually wise to make a visual check of the system piping since a refrigerant leak will often be indicated by the presence of oil. This is because some of the oil in the system will escape through the leak with the refrigerant.

- **Ultra-Sonic.** This type of leak detector is also known as a general area leak detector (the same as the electronic). It will detect a leak no matter what type of gas the system is pressurized with.

Procedures for Detecting Leaks. Methods for leak detection have changed due to some of the old methods of pressurizing systems allowed CFC and HCFCs to escape into the atmosphere, which *is illegal*.

If a high-pressure system has lost its complete charge, it should not be pressurized with refrigerant and leak checked. It *should only be pressurized with dry nitrogen* and then checked with a detecting solution or ultrasonic detector.

When a trace gas must be used to locate a leak that can't be found by other means, R-22 is the only type of refrigerant that has been approved by the Environmental Protection Agency (EPA). This refrigerant causes much less damage to the atmosphere as compared to many other refrigerants.

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Most refrigeration systems are commonly pressurized, for purposes of leak checking, with either dry nitrogen or a combination of R-22 and nitrogen. Test pressures should be adjusted to approximately 150 psig, but not to exceed the nameplate maximum test pressure rating.

Some of the advantages of using a combination of refrigerant (R-22) and nitrogen are:

- Nitrogen is less expensive than refrigerant.
- Test pressures are easier to control.
- Nitrogen will leak at a rate approximately twice as fast as R-22 through the same size hole at the same pressure.
- The electronic leak detector may be used to locate the leak.

If only nitrogen is used to pressurize the system, then liquid bubble type or ultra-sonic detectors can be used to locate the leak.

Nitrogen from a nitrogen cylinder, complete with a pressure regulator and a pressure-relief valve, can be put into the system through the center hose of a gauge manifold similar to the hookup for vapor charging. The pressure in a nitrogen cylinder could be as high as 3,000 psig, so the pressure regulator and pressure-relief valve must be used and must be set for the right pressure. In most cases the nameplate of a piece of equipment in the system will give the recommended test pressure. If the test pressure is not known, NEVER go over 150 psig pressure when doing a leak test on all or part of a system. After the pressure in the system has been built up to the right point, either with nitrogen or a combination of R-22 and dry nitrogen, leaks in refrigerant lines may be detected by the soap solution method or the electronic-detector method.

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SAFETY:

ALWAYS USE A GAUGE EQUIPPED PRESSURE REGULATOR ON THE HIGH PRESSURE NITROGEN GAS AND NEVER INTERCONNECT THE REFRIGERANT CYLINDER AND THE NITROGEN GAS CYLINDER THROUGH A GAUGE MANIFOLD. NITROGEN CYLINDER PRESSURES CAN RUPTURE A REFRIGERANT CYLINDER.

AS YOU HAVE BEEN READING AND STUDYING THIS MATERIAL YOU HAVE READ A LOT ABOUT USING NITROGEN FOR PRESSURIZING THE DIFFERENT TYPES OF APPLIANCES. NOWHERE HAVE YOU EVER READ WHERE OXYGEN IS USED FOR PRESSURIZING A SYSTEM AND THIS IS FOR GOOD REASON. OXYGEN, OR COMPRESSED AIR MIXED WITH REFRIGERANTS UNDER PRESSURE CAN EXPLODE.

Nitrogen is the inert gas that is certified safe for pressurizing, dehydration and purging procedures for any refrigeration system, but there are safety precautions that must be followed. Nitrogen cylinders are under very high pressures, pressures as high as 3,000 PSI. 3,000 PSI is enough to blow apart any hermetic compressor or other system component turning them into bombs of exploding shrapnel. Most refrigeration appliances will only have a certified burst pressure of 500 psig, 3,000 psig far exceeds this pressure.

When using nitrogen, a pressure regulator must be installed on the nitrogen storage cylinder that will drop the pressure leaving the cylinder to a safe working pressure designed for the procedure you are performing. These pressures can range from 1 to 5 psi for purging and dehydration to as high as the design high side test pressure on the equipment name plate for leak testing or blowing debris from a newly installed system.

There should also be a pressure relief valve down stream from the pressure regulator as a precaution in case the pressure regulator becomes defective.

Common sense tells you to never install pressure regulators in series with each other to increase the volume. If you require an increased volume of nitrogen to complete your work, always install the pressure regulators parallel to each other.

If a valve has developed corrosion replace it, do not attempt to take it apart and clean it. This would invalidate the certification all pressure valves must have. This would also expose the mechanic to dangers that a defective valve could cause.

To properly detect leaks, follow these steps:

Step 1: Observe Safety Precautions.

- Don safety equipment.
- Remove jewelry.

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Step 2: Pressurize System.

- Install manifold gauge assembly (MGA).
- Connect Center Hose of MGA to Refrigerant Cylinder.
- Open Low Side MGA Hand Valve until 10 psi is in System.
- Connect Center Hose of MGA to Nitrogen Cylinder.
- Turn Nitrogen Regulator Clockwise until 40 psi is in the hose.
- Open Low Side MGA Hand Valve until 40 psi is in System.

Step 3: Locate Leak.

Step 4: Repair Leak.

Step 5: Repeat Leak Check Procedures (if applicable).

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**Review Questions
for
Locate Refrigerant Leaks**

Question	Answer
1. Refrigeration systems must be absolutely gas tight.	a. True b. False
2. What must the service specialist check before charging a system?	a. Check to insure tools are put away. b. Make sure everything is plugged in. c. Check the power source. d. Check to insure all leaks have been repaired.
3. For any appliance containing more than _____ pounds of refrigerant, the owner must keep a record of all refrigerant charged into that appliance.	a. 50 b. 55 c. 5 d. .50
4. Pressurizing newly installed split systems or built-up systems with HCFC or CFC refrigerants for leak checking is a standard practice.	a. True b. False

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LOCATE REFRIGERANT LEAKS

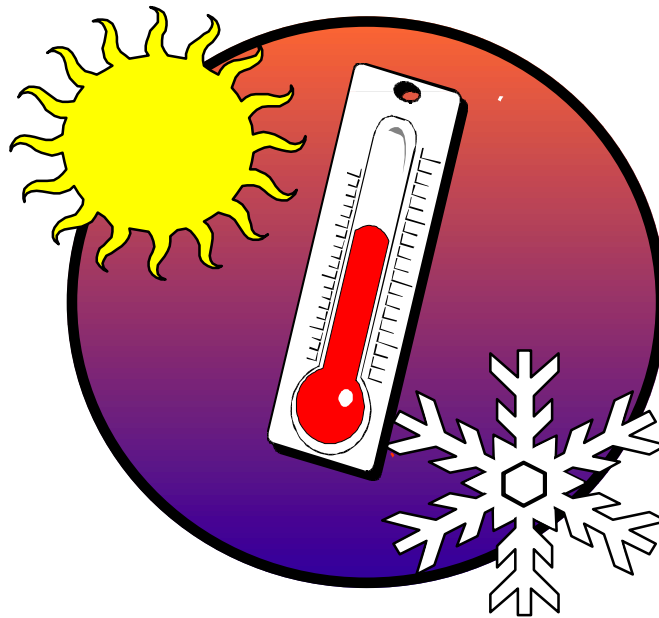
Performance Checklist		
Step	Yes	No
1. Did the trainee demonstrate proper use of soap bubbles?		
a. Swab on suspected leak (Did not shake or pour)		
b. Looked for the presence of bubbles		
2. Did the trainee demonstrate proper use of electronic leak detector?		
a. Probed area slowly		
b. Listen for change in audible indication		
c. Looked for change in visual indication		

NOTE:

Item 2b and 2c are dependent on the type of detector used. Some detectors have only audible indicators while some have both audible and visual.

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

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PROCESS REFRIGERANTS IAW EPA AND AIR FORCE STANDARDS

MODULE 21

AFQTP UNIT 3

OBTAIN UNIVERSAL CERTIFICATION (21.3.2.)

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OBTAIN UNIVERSAL CERTIFICATION

Task Training Guide

STS Reference Number/Title:	21.3.2. Obtain universal certification
Training References:	<ul style="list-style-type: none">• CerTest CD-ROM
Prerequisites:	<ul style="list-style-type: none">• Possess as a minimum a, 3E131 AFSC
Equipment/Tools Required:	<ul style="list-style-type: none">• Computer capable of running the CerTest CD-ROM
Learning Objective:	<ul style="list-style-type: none">• Trainee should understand requirements to obtain universal certification
Samples of Behavior:	<ul style="list-style-type: none">• Trainee should be able to successfully and safely obtain universal certification
Notes:	
<ul style="list-style-type: none">• Any safety violation is an automatic failure.	

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OBTAIN UNIVERSAL CERTIFICATION

Background: The Environmental Protection Agency (EPA) has established a technician certification program for people who perform maintenance, service, repair, or disposal, that could be reasonably expected to release refrigerants into the atmosphere. The definition of technician specifically includes and excludes certain activities. Those activities are shown below:

Included:

- Attaching and detaching hoses and gauges to a system for any reason.
- Adding or removing refrigerant from a system or appliance.
- Any other activity that violates the integrity of the refrigerant circuit while there is refrigerant in the appliance.

Excluded:

- Activities that are not reasonably expected to violate the integrity of the refrigerant circuit, such as washing the unit or troubleshooting the electrical portion of the system.
- Work on units that have already been evacuated in compliance with Environmental Protection Agency (EPA) requirements.

The Environmental Protection Agency (EPA) has developed four classes of certification:

Type I- for servicing small appliances.

Type II- for servicing or disposing of high or very high - pressure appliances.

Type III- for servicing or disposing of low-pressure appliances.

Universal- for servicing all types of equipment.

Technicians are required to pass an Environmental Protection Agency (EPA) approved test given by an EPA approved certifying organization to become certified under the mandatory program.

You must complete the certification program on the CerTest CD-ROM and obtain universal certification. If you have questions concerning this QTP you can call the certifying organization at DSN 736-5793.

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**Review Questions
for
Obtain Universal Certification**

Question	Answer
1. What are the four classes of certification?	a. Type V b. Type III and Universal c. Type I and II d. B and C
2. What technician certification program is required and approved by a certifying organization under the mandatory program?	a. APE b. PEA c. ABC d. EPA

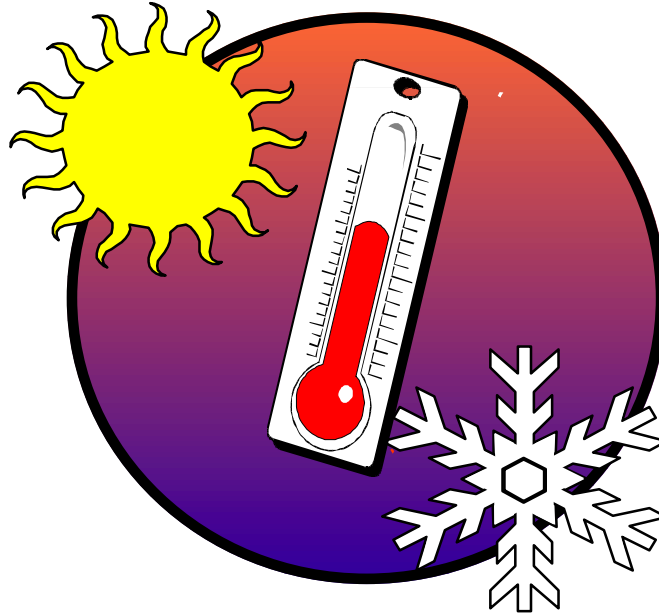
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OBTAIN UNIVERSAL CERTIFICATION

Performance Checklist		
Step	Yes	No
1. Does trainee know why the EPA established a technician certification program for people who perform maintenance, service, repair or disposal?		
2. Does the trainee know the definition of technician specifically that includes and excludes certain activities?		
3. Does the trainee know the four classes of certification?		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

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PROCESS REFRIGERANTS IAW EPA AND AIRFORCE STANDARDS

MODULE 21

AFQTP UNIT 3

RECOVER, RECYCLE, AND RECLAIM REFRIGERANTS FROM REFRIGERATION AND AIR CONDITIONING SYSTEMS (21.3.3.)

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RECOVER, RECYCLE, AND RECLAIM REFRIGERANTS FROM REFRIGERATION AND AIR CONDITIONING SYSTEMS

Task Training Guide

STS Reference Number/Title:	21.3.3. Recover, Recycle, And Reclaim Refrigerants From Refrigeration And Air Conditioning Systems
Training References:	<ul style="list-style-type: none"> • Modern Refrigeration & Air Conditioning • Trane Air Conditioning manual • EPA revision for section 608 of the clean air act • Refrigerant Recycling Rule • ARI-740-1993 protocol or appendix C of the final rule.
Prerequisites:	<ul style="list-style-type: none"> • Possess as a minimum a, 3E131 AFSC.
Equipment/Tools Required:	<ul style="list-style-type: none"> • Personal Protective Equipment (PPE) • Standard HVAC/R tool bag • Manifold Gauge Assembly
Learning Objective:	<ul style="list-style-type: none"> • Trainee should know the standards set by the Environmental Protection Agency (EPA) and the Air Force for Recovering, Recycling, and Reclaiming Refrigerants.
Samples of Behavior:	<ul style="list-style-type: none"> • Trainee can Recover/ Recycle and discuss the procedures governing reclaiming refrigerant.
Notes:	
<ul style="list-style-type: none"> • Any safety violation is an automatic failure. 	

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RECOVER, RECYCLE, AND RECLAIM REFRIGERANTS FROM REFRIGERATION AND AIR CONDITIONING SYSTEMS

Background: Recovery, Recycling, and Reclaiming Refrigerant is defined as the act or acts of removing, cleaning, and processing refrigerant. Any technician opening a system for servicing must use certified recovery equipment, it's the Law and the Environmental Protection Agency (EPA) enforces it. The HVAC/R technician must follow all state and local laws along with Air Force instructions and will also be certified as a Universal Technician. A Universal Technician is defined by the EPA as someone who can work on all three types of systems Type 1 small appliances, Type 2 High pressure equipment, and Type 3 Low pressure and or industrial equipment. You will use any one of these actions daily in the HVAC/R career field, whether you're pulling out some refrigerant to fix a leak, cleaning up a system after a burnout or processing a refrigerant to remove non-condensables. First let's review the terms Recovery, Recycling, and Reclaiming. We'll also look at some of the equipment and how it is used.

- **Recovery.** To remove refrigerant in any condition from a system and store it in an external container. This may be done without necessarily testing or processing the refrigerant in any way.
- **Recycling.** To clean refrigerant for reuse by oil separation and single or multiple passes through devices such as replaceable core filter drier. These devices reduce moisture, acidity, and matter. This term usually applies to procedures implemented at the field job site or at a local service shop.
- **Reclaiming.** To process refrigerant to new product specifications by means which may include distillation. This will require chemical analysis of the refrigerant to determine that appropriate product specifications are met. Reprocessing procedures are usually only available at a processing or manufacturing facility. This also includes on-site or local service shops that are equipped with highly technical equipment.

Refrigerant Recovery/ Recycling Regulatory Requirements. Evacuation requirements; since July 13, 1993, technicians have been required to evacuate air-conditioning and refrigeration equipment to establish vacuum levels when *opening*, the equipment. If the technician's recovery or recycling equipment was manufactured on or after November 15, 1993, the equipment must be evacuated to the levels in the second column of Table 1. The recovery or recycling equipment must have been approved by an EPA approved equipment testing organization (see equipment Certification below). Persons who simply add refrigerant to (top off) appliances are not required to evacuate the systems. Technicians repairing small appliances, such as household refrigerators, window air conditioners, and water coolers must recover:

- 80% of the refrigerant when, the technician uses recovery or recycling equipment manufactured after November 15, 1993 or the compressor is not operating.
- 90% of the refrigerant when, the technician uses recovery or recycling equipment manufactured after November 15, 1993 and the compressor is operating.

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TABLE 1

REQUIRED LEVELS OF EVACUATION FOR APPLIANCES EXCEPT FOR SMALL APPLIANCES, MOTOR VEHICLE AIR CONDITIONERS (MVAC)

Type of Appliance	Before Nov, 15, 1993	On or after Nov, 15, 1993
HCFC-22 appliance, normally containing less than 200 lbs. of refrigerant.	0 PSI	0 PSI
HCFC-22 appliance, normally containing more than 200 Lbs. of refrigerant.	4 HG (inches of mercury)	10 HG
Other high-pressure appliances, normally containing less than 200 Lbs. of refrigerant (CFC-12, 500, 502, 114).	4 HG	10 HG
Other high-pressure appliances, normally containing more than 200 Lbs. of refrigerant (CFC-12, 500, 502, 114).	4 HG	15 HG
Very high-pressure appliance (CFC-13,503).	0 PSI	0 PSI
Low-pressure appliance (CFC-11, HCFC-123).	25 HG	25mm HG absolute

Exceptions to Evacuation Requirements. The Environmental Protection Agency (EPA) has established limited exceptions to its evacuation requirements for, (1) Repairs to leaky equipment (2) Repairs that are not *major* and that are not followed by an evacuation of the equipment to the environment.

1. If, due to leaks the evacuation levels in Table 1 are not attainable, or would substantially contaminate the refrigerant being recovered, persons opening the appliance must:
 - Isolate the leak from non-leaking components wherever possible.
 - Evacuate non-leaking components to the levels in Table 1
 - Evacuate leaking components to the lowest level that can be attained without substantially contaminating the refrigerant. This level cannot exceed 0 psig
2. If evacuation of the equipment to the environment is not to be performed when repairs are complete, and if the repair is not *major*, then the appliance must be:
 - Evacuated to at least 0 psig before it is opened if it is a high or very high-pressure appliance.
 - Pressurized to 0 psig before it is opened if it is a low-pressure appliance, methods that require subsequent purging (e.g. nitrogen) cannot be used except with appliances containing R-113.

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NOTE:

Major repairs are any maintenance, service, or repair that removes any or all of the following components: Compressor, Condenser, Evaporator, or Auxiliary heat exchanger coil.

Reclaiming Certification. The Environmental Protection Agency (EPA) has also established that refrigerant recovered and/or recycled can be returned to the same system or other systems owned by the same person without restriction. If the refrigerant changes ownership however, it must be reclaimed (i.e., cleaned to the Air Conditioning Refrigeration Institute Standard ARI-700 (and chemically analyzed by an EPA approved certifier to verify that it meets the standard).

Equipment Certification. The Environmental Protection Agency (EPA) has established a certification program for recovering and recycling equipment. Under the program the EPA requires that equipment manufactured on or after Nov. 15 1993, be tested by an EPA approved testing organization to insure that it meets all EPA requirements. Recycling and recovery equipment intended for use with air conditioning and refrigeration equipment besides small appliances must be tested under ARI-740-1993 test protocol, which is included in the final rule as Appendix B. Recovery equipment intended for use with small appliances must be tested under either the ARI-740-1993 protocol or Appendix C of the final Rule. The EPA has approved both the Air Conditioning and Refrigeration Institute (ARI) and the Underwriters Laboratory (UL) to certify recycling and recovery equipment. Certified equipment must be labeled as; Equipment has been certified by ARI/UL to meet the EPA's minimum requirements for recycling and or recovery equipment intended for use with (then put in the appropriate category of appliance). The EPA requires that all persons servicing or disposing of air conditioning and refrigeration equipment certify to the appropriate EPA regional office that they have acquired (built, bought or leased) recovery or recycling equipment and that they are complying with the applicable requirements of this rule. This certification must be signed by the owner of the equipment or another responsible officer and sent to the appropriate EPA regional office. Although the owners of the recovery and recycling equipment are required to list the number of trucks they have in their shops, they do not have to have recovery and recycling equipment for every truck. Owners do not need to send in a new form every time they add a piece of recovery or recycling equipment to their inventory.

Reclaimer Certification. Reclaimers are required to return refrigerant to the purity level specified in ARI Standard 700-1993 (an industry set purity standard) and to verify this purity using the laboratory protocol set forth in the same standard. In addition, reclaimers must release no more than 1.5 percent of refrigerant during the reclamation process and must dispose of wastes properly. Reclaimers must certify to the section 608 Recycling Program Manager at EPA Headquarters that they are complying with these requirements and that the information given is true and correct. Certification must also include the name, and address of the reclaimer and a list of equipment used to reprocess and analyze the refrigerant. The EPA encourages reclaimers to participate in third party reclaimer certification programs, such as that operated by ARI. Third party certification can enhance the attractiveness of a reclaimer's product by providing an objective assessment of its purity.

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Refrigerant Handling Safety. Because refrigerants are heavier than air, ventilation is important. Fluorocarbons displace air they can cause a person to lose consciousness and can lead to possible cardiac arrest. If refrigerant contacts the skin it can cause severe frostbite. If splashed into your eye it can and will cause blindness. The following items are the minimum safety items required when handling refrigerant:

- **Rubber Gloves**
- **Safety Glasses And Or Shield**

Recovery, Recycle, and Reclaim Techniques: All of this equipment comes in various types and designs. They all have one common thread, to help the HVAC/R technician recover, recycle, and reclaim refrigerant. You should however follow each manufacturer instruction manual. The following are some common terms and instructions for using this equipment:

Recovery Techniques. Recovery of refrigerants is the least complicated of the three methods for processing refrigerants. Recovery is generally used to remove refrigerants from an appliance for a short time while performing repairs and then put back in the system after the system has been leak checked and determined to be leak proof. To date, it is illegal to sell or put recovered or recycled refrigerant in another owners appliance. You must check with your unit of assignment as to what their regulations are. Not all of the buildings or equipment on your base may be government property. Recovery is also used to remove refrigerants from an appliance to be stored before being turned into a recycle agency that has been certified to perform reclaiming services.

The service technician must never mix different types of refrigerant into the same storage cylinder or single tank because it will be impossible to separate the refrigerants during the reclaim process. Mixed refrigerants must be stored in a separate tank that is clearly marked. The reprocess center will charge the owner/technician for mixing the refrigerant for the extra cost of disposal or send the refrigerant back for disposal. There are electronic testing devices now available that will identify mixed refrigerants and what those mixtures are. This could be a valuable tool for any shop to have. One of the problems you will face during recovery is low ambient temperature, which will slow the recovery process and dehydration time. This problem can be overcome by heating the appliance with heating pads, controlled hot water, or heat lamps.

Never use an open flame or live steam to heat anything containing refrigerant because of the possibilities of explosions and exposure to toxic fumes once the flame comes in contact with the refrigerant. During the recovery process, always use hoses or tubing that are as short as possible and have a diameter that is as large as possible or at least equal to the pump intake on the recovery unit. This will prevent excessive pressure drops. Increased recovery times, increased emission possibilities, and the possibility of the system not being completely evacuated. Always remember when transferring refrigerant from a recovery unit into a refrigeration appliance, to guard against the trapping of liquid refrigerant between service valves.

Notice. This AFQTP is NOT intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

Recovery Equipment. Figure 1 is a typical recovery unit. These units will usually come with a recovery cylinder and they may or may not have a built in scale. The cylinders come in various sizes and are color coded in accordance with EPA standards, with a gray bottom and yellow top. The refrigerant is removed from the system in its present condition and stored in a disposable or transferable cylinder. Recovery is similar to evacuating a system with a vacuum pump. The unit to be recovered is connected from the low side to the recovery unit suction port (for vapor recovery) or it can be hooked to both the low and high side (for liquid recovery), just like the unit in the diagram below. The recovery unit is run until the pressures from the guidelines in Table 1 for the applicable refrigerant and system type are reached. Then the suction valve should be shut off, the system should be left alone for five minutes if there is a rise in pressure above 0 psi it may mean there's still some refrigerant left and you must run the recovery cycle again. The compressor oil from the recovery unit should be changed after every recovery from a compressor burnout. Compressor oil should also be changed before recovery of a different refrigerant. The drier should be changed and the transfer hoses should be evacuated before transferring a different refrigerant. The technician should make sure the cylinders being filled do not go past 80% any more than 80% is unsafe and could cause a cylinder to rupture or a safety valve to release the refrigerant. The 80% mark can be determined by using a scale; some manufacturers have built in scales that shut off automatically at 80%. Always check the manufacturer manual for the machine you are using.

NOTE:

Never "jump out " or bypass any safety switches or automatic shut off controls.



Figure 1, Typical Recovery Unit setup

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Recycling Equipment. Recycling equipment can be separate or combined with recovery equipment. The connections are usually identical for all recoveries, but always follow the manufacturers guidelines. Recycling machines can recover/recycle at the job site or in the shop. Remember it's against the law to recover/recycle refrigerant from one owners system and put it into another, you must check with your unit real property office to see what buildings your unit owns. Recycling as performed by most machines on the market today reduce the contaminants in the refrigerant. This is done through oil separation and filtration of acids, moisture, and particles by using replaceable core drier. The refrigerant is cleaned but not necessarily to manufacture's original specifications of purity. These machines are classed as single pass (one trip through the system) or multi-pass units (multiple trips through the system). On the multi-pass system the refrigerant circulates through the machine for a given amount of time or number of cycles, then the refrigerant is returned to the unit or put into a storage cylinder, (See Figure 2).

Guidelines for Recycling Equipment:

- Properly operate and maintain the recycling equipment per manufacture guidelines. Change filters as recommended. Check the system for leaks.
- Keep the refrigerant contained and keep the air out. Most new units have shutoff valves, these operate automatically as the unit is connected and disconnected.
- Use basic principles of refrigerant flow and heat transfer to aid in the recycling process. When transferring from one container to another, transfer liquid. This will allow transferring without frosting the tanks.
- Always use appropriate refillable containers. Fill to 80% (maximum) of volume with liquid. Do not use disposable or unapproved containers.
- Do not *mix* refrigerants. Mark containers. Thoroughly clean containers and fittings upon completion of recycling



Figure 2, Typical Refrigerant Recovery/Recycling Unit

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Reclaiming Equipment Use. Reclaiming certification and Environmental Protection Agency (EPA) standards were discussed earlier, now let's look at a typical reclaim unit (picture below) and it's mode of operation. This type of unit is available for use with R-12, R-22, R-500, and R502. It is designed for the continuous use required on a long-run recovery/recycling procedure. Remember that for the most part HVAC personnel will either send their refrigerant out to be reclaimed or have a central location on base for reclaiming, however there may be some bases where you will have to be certified to do your own reclaiming. The operation of the system pictured in Figure, 3 are as follows.

- The refrigerant is introduced into the system as either liquid or vapor.
- Refrigerant is violently boiled at high temperature and under extremely high pressure.
- Refrigerant then enters a large, unique separator chamber where the velocity is radically reduced. This allows the vapor at high temperature to rise. During this phase, contaminants-copper chips, carbon, oil, acid, and all other contaminants drop to the bottom of the separator. They will be removed during the "oil out" operation.
- The distilled vapor passes to the air-cooled condenser and is converted to a liquid.
- The liquid passes into the on-board storage chamber(s), an evaporator assembly lowers the liquid temperature. It is lowered approximately 100 Degrees Fahrenheit (56 Degrees Celsius) to a sub-cooled temperature of 38 degrees Fahrenheit (3 Degrees Celsius).
- A replaceable filter drier removes the moisture as well as the microscopic contaminants.
- Chilling the refrigerant also facilitates the transfer to any external cylinders, which are at room temperature.

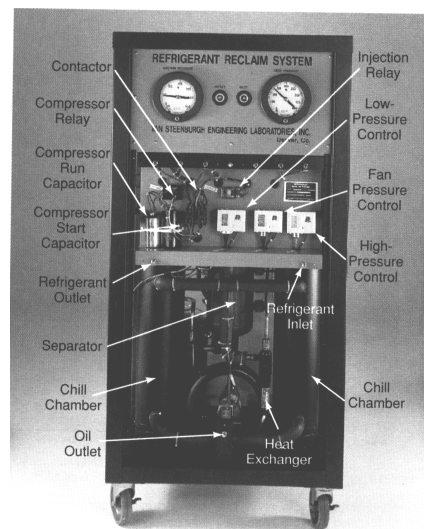


Figure 3, Typical reclaim unit

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**Review Questions
for
RECOVER, RECYCLE, AND RECLAIM REFRIGERANTS FROM REFRIGERATION
AND AIR CONDITIONING SYSTEMS**

Questions	Answers
1. Recycling refrigerant is the act of bringing the refrigerant to factory specifications.	a. True b. False
2. The EPA is the only authority able to certify recovery equipment.	a. True b. False
3. Very high-pressure appliances containing CFC-503 must be evacuated to what pressure?	a. 4 hg b. 15 hg c. 0 psi d. 5 psi
4. In reclaim equipment how is the refrigerant introduced to the equipment?	a. As a liquid b. As a vapor c. As a solid d. As either liquid or vapor
5. If refrigerant contacts the <u>skin</u> it can cause?	a. Blindness b. Baldness c. Frostbite d. Athletes foot
6. All HVAC/R personnel in the Air Force will be certified as a _____.	a. Type 1 technician. b. Type 2 technician. c. Type 3 technician. d. Universal technician.

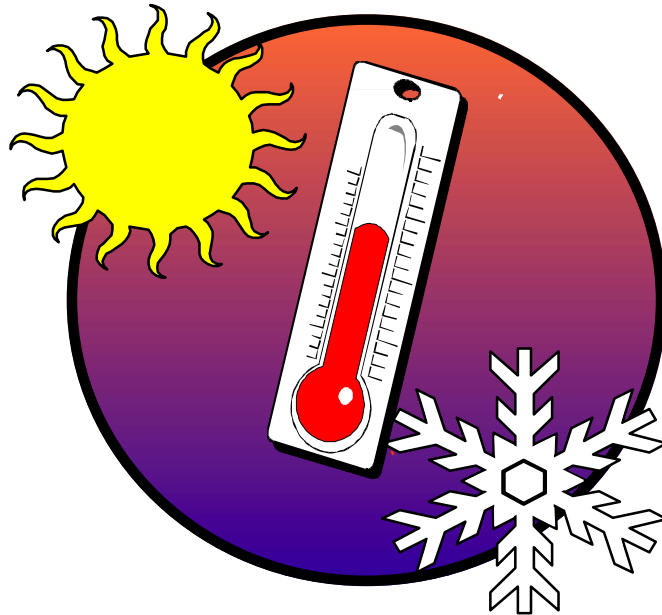
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**RECOVER, RECYCLE, AND RECLAIM REFRIGERANTS FROM REFRIGERATION
AND AIR CONDITIONING SYSTEMS**

Performance Checklist		
STEP	Yes	No
1. Did trainee explain the EPA standards for recovering refrigerant and using manufacturers guide to <u>safely recover</u> refrigerant from a system?		
2. Did trainee explain EPA standards for recycling refrigerant and using manufacturers guide to <u>safely recycle</u> refrigerant taken from a system?		
3. Did trainee explain EPA standards for reclaiming refrigerant and <u>EXPLAIN</u> the use of a reclaim unit?		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will insure the issue is still fresh in the mind of both the trainee and the trainer.

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PROCESS REFRIGERANTS IAW EPA AND AIR FORCE STANDARDS

MODULE 21

AFQTP UNIT 3

PUMP DOWN REFRIGERATION SYSTEMS (21.3.4.)

Notice. This AFQTP is NOT intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

PUMP DOWN REFRIGERATION SYSTEMS

Task Training Guide

STS Reference Number/Title:	21.3.4. Pump Down Refrigeration Systems
Training References:	<ul style="list-style-type: none">• Modern Refrigeration & Air Conditioning• Trane Air Conditioning Manual
Prerequisites:	<ul style="list-style-type: none">• Possess as a minimum a, 3E131 AFSC.
Equipment/Tools Required:	<ul style="list-style-type: none">• Personnel Protection Equipment (PPE)• Standard HVAC/R Tool Bag• Manifold Gauge Assembly
Learning Objective:	<ul style="list-style-type: none">• Trainee should understand the purpose for and know the methods of pumping down a refrigerant system.
Samples of Behavior:	<ul style="list-style-type: none">• Trainee should know how to pump down a system.
Notes:	
<ul style="list-style-type: none">• Any safety violation is an automatic failure.	

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PUMP DOWN REFRIGERATION SYSTEMS

Background: Pumping down a system is defined as the act of using the compressor to move and store the refrigerant to the receiver or condenser. For any service work requiring access to the compressor or the sealed part of the system, the refrigerant must first be removed. On any system with a receiver, the refrigerant can be pumped into the condenser and receiver and isolated there. Pump down is also used as a means of isolating the refrigerant and preventing migration to the compressor crankcase during periods of shipment, storage, or non-operating off cycles. On small systems without service valves or pump down control, it may be necessary to remove the refrigerant charge prior to servicing the equipment, and then recharge the system when put back in service.

SAFETY:

MAKE CERTAIN THAT LIQUID REFRIGERANT IS NOT TRAPPED IN THAT PART OF THE SYSTEM BEING OPENED. GOGGLES SHOULD BE WORN WHEN WORKING WITH REFRIGERANTS. THERE HAVE BEEN NUMEROUS ACCIDENTS, RESULTING IN BLINDNESS AND OTHER SERIOUS INJURIES.

SAFETY:

DO NOT PUT A FLAME ON A SYSTEM CONTAINING REFRIGERANT. THIS WILL CAUSE R-12, R-22 AND OTHER HCFC AND CFC REFRIGERANTS TO DECOMPOSE AND FORM HYDROCHLORIC, HYDROFLUORIC ACIDS AS WELL AS PHOSGENE GAS, WHICH IS POISONOUS TO INHALE.

Method: The pump down procedure is accomplished by closing the valve at the outlet of the receiver or condenser while the compressor is operating. Since no further refrigerant can flow to the evaporator, the refrigerant is pumped out of the evaporator and into the condenser. Check the operating pressures by means of a manifold gauge and when the suction pressure reaches 1 to 5 psig, stop the compressor.

NOTE:

If the unit is equipped with a low-pressure control having a higher setting, it will be necessary to bypass the low-pressure control in order to keep the compressor operating while pumping the system down.

Observe the MGA, if the pressure rises rapidly, then more than likely there is still residual refrigerant boiling off in the system. Start the compressor and again pump the suction pressure down to 1 to 5 psig. This may need to be repeated several times. In the event the pressure should drop into a vacuum and remain there for several minutes, disconnect power from the compressor, and crack the receiver valve momentarily to introduce sufficient refrigerant to obtain a slight positive pressure (1 to 5 psig).

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The liquid line, the low-pressure side of the system, and the compressor should now be at a slight positive pressure (Approximately 1 to 5 psig). Use the proper tools to remove any positive pressure that remains in the system. You now can remove and replace the component in question or correct the malfunction, (i.e., fix the leak).

NOTE:

If it is necessary to remove or gain access to the discharge line, condenser, or receiver, pumping the system down is of no benefit, and the refrigerant charge must be removed unless there are valves to isolate the defective component.

Review Questions for Pump Down Refrigeration Systems

Question	Answer
1. The act of <i>using the compressor</i> to move and store the refrigerant in the receiver or condenser is defined as pump down.	a. True b. False
2. At what pressure is the compressor stopped?	a. 1-5 PSIG b. 2-6 PSIG c. 7-9 PSIG d. 10-11 PSIG
3. For any service work requiring access to the compressor or the sealed part of the system, the refrigerant must first be removed.	a. True b. False
4. The pump down procedure is accomplished by closing the valve at the outlet of the receiver or condenser while the _____ is operating.	a. Compressor b. Condenser c. Receiver d. Evaporator
5. If it is necessary to remove or gain access to the discharge line, condenser, or receiver, pumping the system down is of no benefit, and the refrigerant charge must be removed unless there are valves to isolate the defective component.	a. True b. False

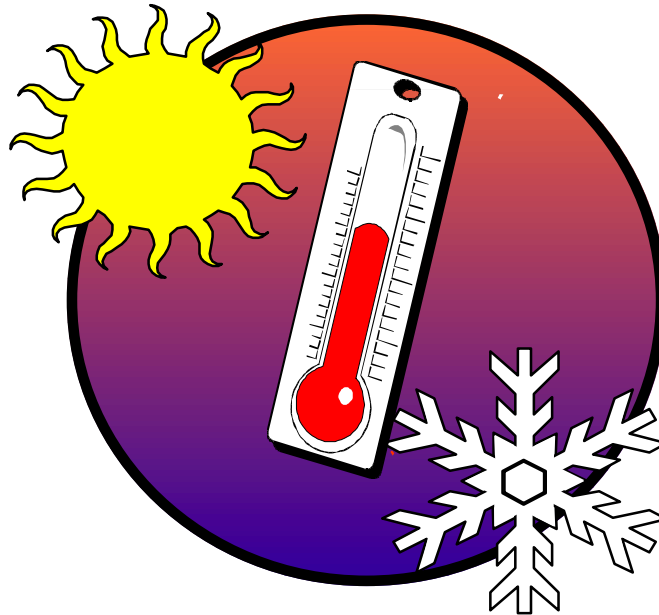
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PUMP DOWN REFRIGERATION SYSTEM

Performance Checklist		
Step	Yes	No
1. Safety		
a. Remove jewelry?		
b. Don personnel protection equipment (PPE)?		
2. Shut off system (if applicable)?		
3. Connect manifold gauge assembly?		
4. Attach both ends of center hose to manifold?		
5. Crack high-side manifold gauge assembly (MGA) hand valve momentarily?		
6. Bleed air from center hose?		
7. Close king valve or pump down control?		
8. Back seat discharge service valve?		
9. Ensure suction service valve is gauged?		
10. Start compressor?		
11. Stop compressor when 1 - 5 psig is achieved?		
12. Monitor - Repeat 9 and 10 if necessary to maintain 1-5 psig?		
13. Back seat suction service valve?		
14. Remove gauges?		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

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PROCESS REFRIGERANTS IAW EPA AND AIR FORCE STANDARDS

MODULE 21

AFQTP UNIT 3

PRESSURE CHECK REFRIGERATION SYSTEMS (21.3.5.)

Notice. This AFQTP is NOT intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

PRESSURE CHECK REFRIGERATION SYSTEMS

Task Training Guide

STS Reference Number/Title:	21.3.5. Pressure Check Refrigeration Systems
Training References:	<ul style="list-style-type: none">• Modern Refrigeration & Air Conditioning• Trane Air Conditioning Manual
Prerequisites:	<ul style="list-style-type: none">• Possess as a minimum a, 3E131 AFSC.
Equipment/Tools Required:	<ul style="list-style-type: none">• Personnel Protective Equipment (PPE).• Standard HVAC/R Tool Bag.• Manifold Gauge Assembly.
Learning Objective:	<ul style="list-style-type: none">• Trainee should understand the purpose for and know the methods of checking system pressure.
Samples of Behavior:	<ul style="list-style-type: none">• Trainee should know how to check system pressure.
Notes:	
<ul style="list-style-type: none">• Any safety violation is an automatic failure.	

Notice. This AFQTP is NOT intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

PRESSURE CHECK REFRIGERATION SYSTEMS

Background: Frequently a technician may need to determine if a refrigeration system is functioning normally. That is, he/she may need to know if a system actually has a trouble or not. *Check system pressures by connecting a manifold gauge set to the suction and discharge lines.* It is then possible to determine if the suction and discharge pressures are within the normal operating range for a particular unit. Consider the operating conditions, (e.g., the outdoor ambient temperature and its affect upon discharge pressure.)

Manifold Gauge Assembly:

- **Manifold.** The manifold has 3 ports to connect service hoses. The port on each end of the manifold will be used to take readings of the high and low side of a system while the center port is used for recovery, charging and evacuation of a system.
- **Gauges.** The MGA (manifold gauge assembly) or set consists of 2 pressure gauges. Pressure gauges, especially calibrated for refrigeration usage, are the primary tool of the service person in checking system performance. Gauges for the high-pressure side of the system have scales reading from 0 psig to 500 psig. Gauges for the low-pressure part of the system are termed compound gauges, since the scale is graduated for pressures above atmospheric pressure in psig, and for pressures below atmospheric pressure in vacuum in inches of mercury. The compound gauge is calibrated from 30 inches of vacuum to pressures ranging to 150 psig.

Generally, the high side gauge will be color-coded red, while the low side gauge will be color-coded blue. The low side gauge will have increments of PSIG for pressures above 0-PSIG and inches of mercury (HG) for measuring vacuum. The high side gauge will have increments from 0 to 500 PSI. Even though some high side gauges will show a vacuum scale it is not used to measure vacuum. This part of the gauge is only there to protect the pointer from being thrown out of calibration if the gauge is exposed to vacuum pressures. In addition to the pressure scales, equivalent saturation temperatures for commonly used refrigerants are usually shown on the gauge dial.

Care and Use of the Manifold Gauge Assembly (MGA):

- Never drop or abuse the gauge manifold.
- Keep ports or charging lines capped when not in use.
- Never use with any fluid other than clean oil and refrigerant.
- Have gauges checked and adjusted regularly.
- Never subject gauges to pressures higher than scale face maximum or high-pressure gauge to a vacuum.
- Ensure hoses meet high-pressure requirements.
- Prevent hoses from being chafed, crushed or stretched.

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Installation and Removal of the Manifold Gauge Assembly (MGA):

SAFETY:

REMOVE JEWELRY DON SAFETY GOGGLES AND NEOPRENE GLOVES.

To perform the task, follow these steps:

Install Manifold Gauge Assembly (MGA).

Step 1: Observe Safety Precautions.

Step 2: Remove Service Valve Stem Caps.

Step 3: Back Seat Service Valves.

Step 4: Remove Dust Covers on Service Ports.

Step 5: Connect MGA Hoses to Service Ports.

Step 6: Gauge Service Valves.

Remove Manifold Gauge Assembly (MGA):

To perform the task, follow these steps:

Step 1: Back Seat Discharge Service Valve.

Step 2: Back Seat Suction Service Valve.

Step 3: Remove MGA Hoses.

Step 4: Install Dust Covers on Service Ports.

Step 5: Install Service Valve Stem Caps.

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**Review Questions
for
Pressure Check Refrigeration Systems**

Question	Answer
1. The manifold has 3 ports to connect service hoses.	a. True b. False
2. What pressure gauge indicates pressure both above and below atmospheric pressure?	a. Compound gauge b. Valve stem gauge c. Dust cover gauge d. Manifold gauge
3. What color is the low side gauge?	a. Purple b. Red c. Blue d. Orange
4. What color is the high side gauge?	a. Red b. Blue c. Purple d. White

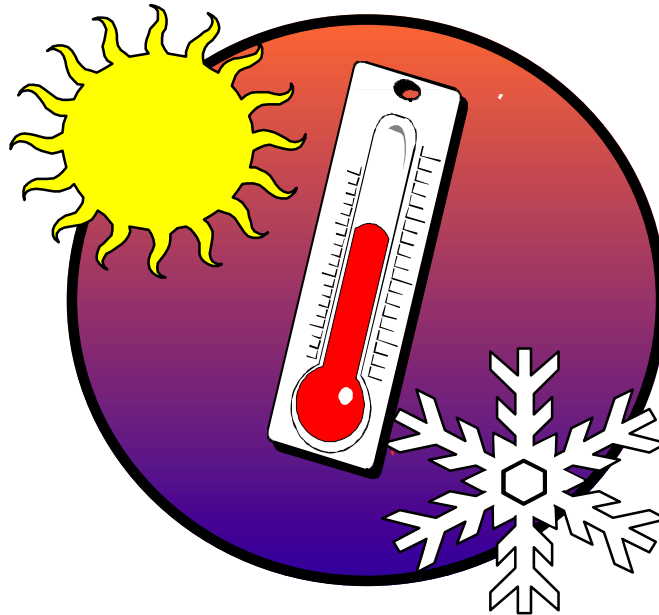
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PRESSURE CHECK REFRIGERATION SYSTEMS

Performance Checklist		
Step	Yes	No
1. Safety:		
a. Remove Jewelry?		
b. Don Safety Goggles and Leather Gloves?		
2. Install Manifold Gauge Assembly:		
a. Observe Safety Precautions?		
b. Remove Service Valve Stem Caps?		
c. Back Seat Service Valves?		
d. Remove Dust Covers on Service Ports?		
e. Connect MGA Hoses to Service Ports?		
f. Gauge Service Valves?		
3. Remove Manifold Gauge Assembly:		
a. Back Seat Discharge Service Valve?		
b. Back Seat Suction Service Valve?		
c. Remove MGA Hoses?		
d. Install Dust Covers on Service Ports?		
e. Install Service Valve Stem Caps?		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

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PROCESS REFRIGERANTS IAW EPA AND AIR FORCE STANDARDS

MODULE 21

AFQTP UNIT 3

CHARGE HVAC/R SYSTEMS WITH REFRIGERANT (21.3.6.)

Notice. This AFQTP is NOT intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

CHARGE HVAC/R SYSTEMS WITH REFRIGERANT

Task Training Guide

STS Reference Number/Title:	21.3.6. Charge HVAC/R Systems with Refrigerant
Training References:	<ul style="list-style-type: none">• Modern Refrigeration & Air Conditioning• Trane Air Conditioning Manual
Prerequisites:	<ul style="list-style-type: none">• Possess as a minimum a, 3E131 AFSC.
Equipment/Tools Required:	<ul style="list-style-type: none">• Personnel Protective Equipment (PPE).• Standard HVAC/R Tool Bag.• Manifold Gauge Assembly.
Learning Objective:	<ul style="list-style-type: none">• Trainee should know the methods of charging a refrigerant system.
Samples of Behavior:	<ul style="list-style-type: none">• Trainee should know how to charge a refrigerant system.
Notes:	
<ul style="list-style-type: none">• Any safety violation is an automatic failure.	

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CHARGE HVAC/R SYSTEMS WITH REFRIGERANT

Background: All mechanical-cooling systems do not use the same refrigerant. Also, all systems do not use the same amount of refrigerant, even though the cooling capacities may be near the same. So it is quite important to know which refrigerant should be placed in the system, and how much of the refrigerant should be used. On factory-assembled systems, the nameplate should be looked at before any charging is to be done. The nameplate will show which refrigerant is to be used in the system, and sometimes it will show the amount of charge that is needed. Before an attempt to charge the system is made, the system should be *leak checked and all leaks repaired*.

Methods for Determining Correct Charge:

- **Weighing the Charge.** The most accurate charging procedure is to actually weigh the refrigerant charged into the system. This can **ONLY** be done when the system requires a full charge and the amount of charge is known. Normally such data is available on packaged unitary equipment.
- **Sight Glass.** Since a solid head of liquid refrigerant is essential for proper expansion valve control, the system can be considered properly charged when a clear stream of liquid refrigerant is visible. Bubbles or flashing ***MAY*** indicate a shortage of refrigerant. Bear in mind that if there is vapor and no liquid in the sight glass, it will also appear clear. The technician should be aware that at times the sight glass *may show bubbles or flash gas even when the system is fully charged*. A restriction in the liquid line ahead of the sight glass may cause sufficient pressure drop to cause flashing of the refrigerant. If the expansion valve feed is erratic or surging, the increased flow when the expansion valve is wide open can create sufficient pressure drop to create flashing at the receiver outlet. Rapid fluctuations in condensing pressure can be a source of flashing. While the sight glass can be a valuable aid in determining the proper charge, the *system performance must be carefully analyzed before placing full reliance on it* as a positive indicator of the system charge.
- **Charging By Superheat.** If a service port is available so that the suction pressure can be determined, the superheat may be calculated by determining the difference between the temperature of the suction line at the evaporator outlet and the saturation temperature equivalent of the suction pressure. With the unit running at its normal operating condition, continue charging until the superheat is determined to be between 8° and 12° F. A superheat below 8° F. indicates an overcharged condition, a superheat above 12° F. indicates an undercharge.

SAFETY:

ALWAYS WEAR NEOPRENE GLOVES AND GOGGLES WHEN CHARGING A REFRIGERANT SYSTEM. REFRIGERANT CAN FREEZE FINGERS AND EYES ON CONTACT CAUSING PERMANENT LOSS OF FUNCTION AND RUIN YOUR DAY.

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

- **Ambient Temperature Method.** To check for proper charge using this method, take a temperature reading of the cooling medium for the condenser (ambient temperature). Then add the condensing factor for the type of condenser used:
 - **Natural Draft Condenser** **35° F.**
 - **Forced Draft Condenser** **30° F.**
 - **Water Cooled Condenser** **25° F.**

Using a Pressure and Temperature (P/T) chart, convert the sum of the above temperature to pressure for the refrigerant in use. This pressure should be approximately the same as the high side pressure that the unit is operating at.

Charging Procedures. There are two ways of charging refrigerant systems.

- **Vapor-Charging.** Small systems are in most cases vapor charged through the gauge port of the compressor suction valve. The following steps should be followed to make sure that the system would get the right amount of refrigerant charge.
- **Liquid-Charging.** Charging refrigerant in the liquid state is used for larger systems where vapor charging would take too long. If a complete charge is to be put in a large evacuated system, the liquid in many cases is charged through the liquid-line service valve while the compressor is not in operation. The procedure for attaching the service-gauge manifold and the purge lines is the same as that shown for vapor charging above. When it is necessary to charge with liquid from the disposable type drum, invert the drum to obtain liquid refrigerant. Some reusable cylinders have different valves that allow a choice of gas or liquid charging.

To perform the task, follow these steps:

Step 1: Don Personnel Protective Equipment (PPE).

- Neoprene gloves
- Goggles

Step 2: Back Seat the suction-line service valve.

Step 3: Connect the line from the low side of the manifold gauge assembly (MGA) to the suction-line service valve gauge port.

Step 4: Gauge the suction service valve and momentarily open the low-side valve of the gauge manifold.

Step 5: Back Seat the discharge service valve.

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Step 6: Connect the line from the high side of the MGA to the discharge service valve gauge sort.

Step 7: Gauge the discharge service valve and momentarily open the high-side valve of the manifold gauge.

Step 8: Connect the centerline from the manifold to the refrigerant cylinder.

Step 9: Purge the line with vapor from the cylinder to the manifold gauge assembly by momentarily opening the valve on the refrigerant cylinder. Be sure that the cylinder is upright.

Step 10: Open the valve on the refrigerant cylinder and charge the system using one or more charging methods.

Step 11: Start the compressor and wait until the head pressure and the suction pressure stabilize. If the system is built with a low-pressure control that starts to short cycle the compressor, note the cutout pressure and admit refrigerant from the cylinder to increase the suction pressure by 10 to 15 lb. over this cutout setting. Open the cylinder valve wide and control the flow of refrigerant by the valve on the low side of the service-gauge manifold. From time to time close the cylinder valve and check the suction pressure. Also, periodically check the head pressure to make sure that it does not rise above what would be expected under normal operating conditions. If the cylinder pressure drops too low for further charging before the job is finished, place the cylinder in a pan or bucket of warm water (80° to 110° F.) or use a heat lamp to increase the pressure. Do not apply heat with a torch. Never heat the cylinder over 125° F.

Step 12: When the proper amount of refrigerant has been introduced into the system, close the cylinder valve and the low-side valve on the gauge manifold, then disconnect the charging line.

Step 13: When the system is operating, as it should. Back seat the suction-line and discharge service valves and bleed pressure from both gauge lines through the gage manifold charging port. Disconnect the gauge lines from the suction-line and discharge service valves.

Step 14: Replace the refrigerant cylinder cap or cylinder valve cover, and place flare plugs in the open ends of the charging and gauge lines.

Step 15: Replace the caps on the gauge ports of the service valves.

SAFETY:

**DO NOT APPLY HEAT WITH A TORCH. THIS MAY CAUSE THE DRUM TO EXPLODE.
NEVER HEAT THE CYLINDER OVER 125 DEGREES F.**

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Review Questions
for
Charge HVAC/R Systems with Refrigerant

Question	Answer
1. What is the most accurate charging procedure?	a. Weight b. Ambient c. Superheat d. Sight glass
2. A sight glass will show bubbles if the system has _____.	a. Vapor in the liquid line b. The unit is properly charged c. The unit is improperly charged d. All of the above
3. What is the proper superheat range when the system is properly charged?	a. 10-15 PSI b. 10-15 Degrees F c. 8-12 PSI d. 8-12 Degrees F
4. There are two ways of charging refrigerant systems; _____ and _____.	a. Vapor and Liquid b. Ambient and Refrigerant c. Gauge and Cylinder d. Natural and Forced

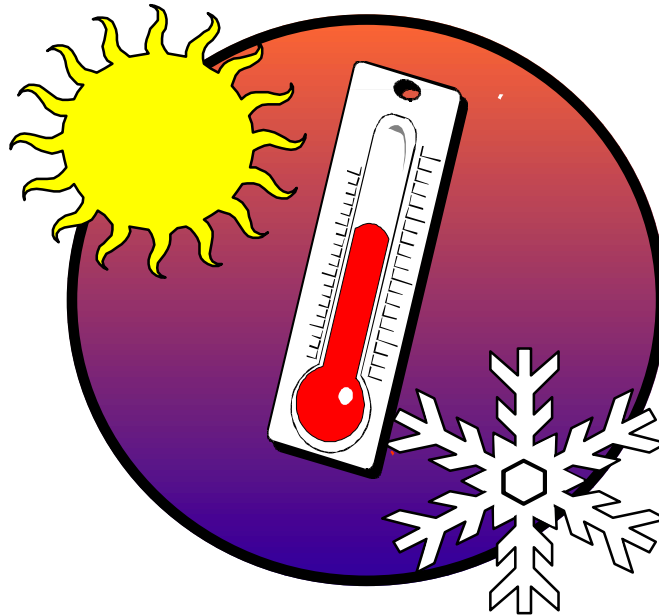
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CHARGE HVAC/R SYSTEMS WITH REFRIGERANT

Performance Checklist		
Step	Yes	No
1. Safety		
a. Remove jewelry?		
b. Don safety equipment?		
2. Connect Cylinder to System		
a. Install MGA?		
b. Connect Center Hose of MGA to Refrigerant Cylinder?		
c. Open Refrigerant Cylinder Valve 1/4 Turn?		
d. Momentarily Loosen Center Hose at MGA?		
3. Charge System		
a. Open Low Side MGA Hand Valve?		
b. Turn On Unit		
c. Charge to Proper Amount using one of the following methods (Students choice):		
1. Check Superheat?		
2. Charge by using the Ambient Temperature Method?		
3. Check the Sight Glass?		
4. Close Low Side MGA Hand Valve?		
5. Disconnect Cylinder From System		
a. Close Refrigerant Cylinder Valve?		
b. Remove MGA Center Hose from Cylinder?		
c. Remove MGA?		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

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REPAIR

MODULE 21

AFQTP UNIT 5

TROUBLESHOOT (21.5.3.12.1.)

CORRECT MALFUNCTIONS (21.5.3.12.2.)

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TROUBLESHOOT
CORRECT MALFUNCTIONS

Task Training Guide

STS Reference Number/Title:	21.5.3.12.1. Troubleshoot 21.5.3.12.2. Correct Malfunctions
Training References:	<ul style="list-style-type: none">• Modern refrigeration and air conditioning• Trane air conditioning manual• Copeland air-conditioning manual
Prerequisites:	<ul style="list-style-type: none">• Possess as a minimum a, 3E131 AFSC.
Equipment/Tools Required:	<ul style="list-style-type: none">• Personnel Protective Equipment.• Standard HVAC tool bag.
Learning Objective:	<ul style="list-style-type: none">• Select correct instruments for troubleshooting mechanical and electrical problems in an AC system.• Determine standard operating suction and discharge pressures.• Check line and low voltage power supplies.• Troubleshoot basic electrical problems.
Samples of Behavior:	<ul style="list-style-type: none">• Trainee should know how to troubleshoot and repair mechanical problems in an AC system.• Trainee should know how to trouble shoot and repair electrical problems.
Notes:	
<ul style="list-style-type: none">• Any safety violation is an automatic failure.	

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TROUBLESHOOT

CORRECT MALFUNCTIONS

Background: To begin troubleshooting any area of an air-conditioning system, you need some idea of what the typical conditions should be. In commercial air-conditioning we may be dealing with air temperatures inside the conditioned space or outside at the condenser. We may need to know the current draw of the compressor or fan motors. The pressures inside the system may be important for troubleshooting and diagnosis. There are many conditions both outside and within the system that are important to know and understand. Knowing how the equipment is supposed to be functioning helps. You should know how it is supposed to sound, where it should be cool or hot, and when a particular fan is supposed to be operating. Knowing the correct operating pressures for a typical system can help you get started. After studying this unit, you should be able to select the correct instruments for checking an air conditioning unit with a mechanical problem. Determine the standard operating suction pressures for standard and high efficiency equipment. Calculate the correct operating suction pressures for both standard- and high-efficiency equipment with other-than-design conditions. Calculate the standard operating discharge pressures at various ambient conditions. Select the correct instruments to troubleshoot electrical problems in an air conditioning system. Check the line and low-voltage power supplies. Troubleshoot basic electrical problems in an air conditioning system. Use an ohmmeter to check the various components of the electrical system.

SAFETY:

BE EXTREMELY CAREFUL WHEN INSTALLING OR REMOVING GAUGES. ESCAPING REFRIGERANT CAN INJURE YOUR SKIN AND EYES. ALWAYS WEAR GLOVES AND GOGGLES. IF POSSIBLE, TURN OFF THE SYSTEM TO INSTALL A GAUGE ON THE HIGH-PRESSURE SIDE. MOST AIR CONDITIONING SYSTEMS ARE DESIGNED SO THAT THE PRESSURES WILL EQUALIZE WHEN TURNED OFF.

SAFETY:

WEAR GOGGLES AND GLOVES WHEN TRANSFERRING REFRIGERANT FROM A CYLINDER TO A SYSTEM OR WHEN RECOVERING REFRIGERANT FROM A SYSTEM. DO NOT RECOVER REFRIGERANT INTO A DISPOSABLE CYLINDER. USE ONLY TANKS OR CYLINDERS APPROVED BY THE DEPARTMENT OF TRANSPORTATION (DOT).

SAFETY:

BE VERY CAREFUL WHEN WORKING AROUND A COMPRESSORS DISCHARGE LINE THE TEMPERATURE MAY BE AS HIGH AS 220 DEGREES F.

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SAFETY:

ALL SAFETY PRACTICES MUST BE OBSERVED WHEN TROUBLESHOOTING ELECTRICAL SYSTEMS. OFTEN, READINGS MUST BE TAKEN WHILE THE POWER IS ON. LET THE INSULATED METER LEADS TOUCH THE HOT TERMINALS NEVER USE A SCREWDRIVER OR OTHER TOOLS AROUND TERMINALS THAT ARE ENERGIZED. NEVER USE TOOLS IN A HOT ELECTRICAL PANEL.

SAFETY:

TURN THE POWER OFF WHENEVER POSSIBLE WHEN WORKING ON A SYSTEM LOCK AND TAG THE DISCONNECT PANEL AND KEEP THE ONLY KEY ON YOUR PERSON. SHORT CAPACITOR TERMINALS WITH A 20,000^Ω RESISTOR BEFORE CHECKING WITH AN OHMMETER. INEXPERIENCED PERSONS SHOULD PERFORM TROUBLESHOOTING TASKS ONLY UNDER THE SUPERVISION OF AN EXPERIENCED PERSON. DO NOT STAND IN WATER WHEN MAKING ANY ELECTRICAL MEASUREMENTS.

Mechanical Troubleshooting: Troubleshooting air conditioning equipment involves troubleshooting mechanical and electrical systems and they may have symptoms that overlap. For example, if an evaporator fan motor capacitor fails, the motor will slow down and begin to get hot. It may even get hot enough for the internal overload protector to stop it. While it is running slowly, the suction pressure will go down and give symptoms of a restriction or low charge. If the technician diagnoses the problem based on suction pressure readings only, a wrong decision may be made.

It is helpful to keep in mind, that when a piece of equipment has been running well for some period of time without noticeable problems, that *normally only one problem* will trigger any sequence of events that may be encountered. For instance, it is common for the technician to approach a piece of equipment and think that two or three components have failed at one time. *The chance of two parts failing at once is remote, unless one part causes the other to fail.* These failures can almost always be traced to one original cause. Gauges and temperature-testing equipment are used when performing mechanical troubleshooting. The gauges used are those on the gauge manifold as shown in Figure 1. The suction or low-side gauge is on the left side of the manifold and the discharge or the high-side gauge is on the right. The most common refrigerant used in air conditioning is R-22. An R-22 temperature chart is printed on each gauge for determining the saturation temperature for the low- and high-pressure sides of the system. Because these same gauges are used for refrigeration, a temperature scale for R-12 and R-502 is printed on the gauge also. The R-12 scale is not used for residential air conditioning unless the equipment is old enough that R-12 is used. *The common refrigerant for automobile air conditioning starting in 1992 is R-134a. *Older automobiles would normally use R-12.

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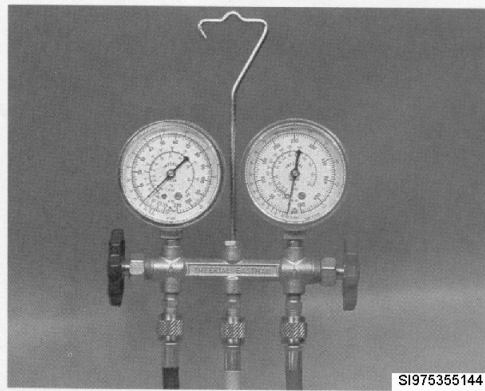


Figure 1, Low-side gauge on the left and high-side gauge on the right.

Manifold gauge usage. The manifold gauge displays the low-side and high-side pressures while the unit is operating. These pressures can be converted to the saturation temperatures for the evaporating (boiling) refrigerant and the condensing refrigerant by using the pressure and temperature relationship. The low-side pressure can be converted to the boiling temperature. If the boiling temperature for a system should be close to 40°F, it can be converted to 70 psig for R-22.

The superheat at the evaporator should be close to 10°F at this time. It is difficult to read the suction pressure at the evaporator because it normally has no gauge port. Therefore, the technician takes the pressure and temperature readings at the condensing unit suction line to determine the system performance. Guidelines for checking the superheat at the condensing unit will be discussed later in this unit. If the suction pressure were 48 psig, the refrigerant would be boiling at about 24°F, which is cold enough to freeze the condensate on the evaporator coil and too low for continuous operation. The probable causes of low boiling temperatures are low charge or restricted air flow, (Figure, 2).

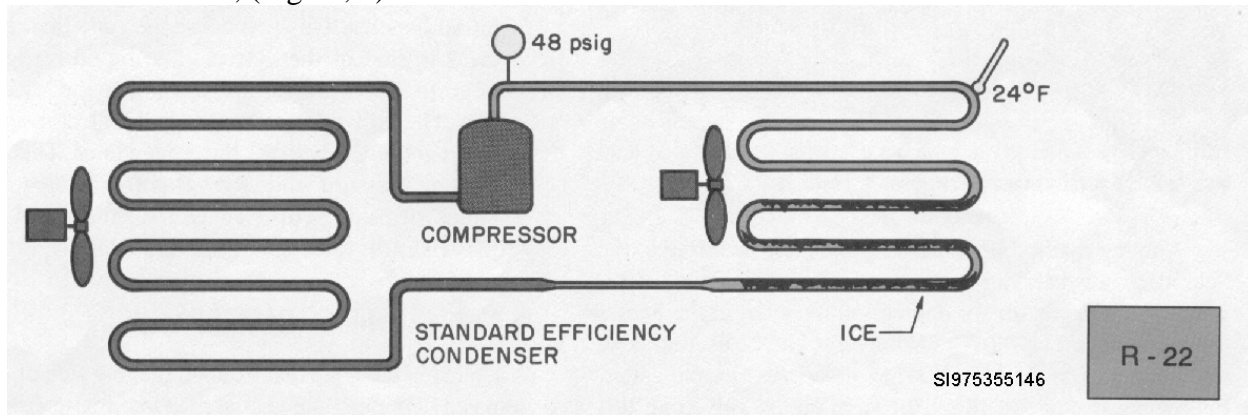


Figure 2, This coil was operated below freezing until the condensate on the coil froze.

SAFETY:

YOU MUST BE EXTREMELY CAREFUL WHILE INSTALLING MANIFOLD GAUGES. HIGH-PRESSURE REFRIGERANT WILL INJURE YOUR SKIN AND EYES. WEARING GOGGLES AND GLOVES ARE NECESSARY. THE DANGER FROM ATTACHING THE HIGH PRESSURE GAUGES CAN BE REDUCED BY SHUTTING OFF THE UNIT AND ALLOWING THE PRESSURES TO EQUALIZE TO A LOWER PRESSURE. LIQUID R-22 CAN CAUSE SERIOUS FROSTBITE BECAUSE IT BOILS AT 44 F AT ATMOSPHERIC PRESSURE.

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The high-side gauge may be used to convert pressure to condensing temperatures. For example, if the high-side gauge reads 278 psig and the outside ambient temperature is 80°F, the head pressure may seem too high. The manifold gauge chart shows that the condenser is condensing at 125°F. However, a condenser should not condensate at a temperature more than 30°F higher than the ambient temperature. The ambient temperature is $80^{\circ}\text{F} + 30^{\circ}\text{F} = 110^{\circ}\text{F}$, so the condensing temperature is actually 15°F too high. Probable causes are a dirty condenser or an overcharge of refrigerant.

The manifold gauge is used whenever the pressures need to be known. Two Types of pressure connections are used with air conditioning equipment; the schrader valve and the service valve, as shown in Figures 3 and 4. The schrader valve is a pressure connection only. The service valve can be used to isolate the system for service. It may have a Schrader connection for the gauge port and a service valve for isolation.

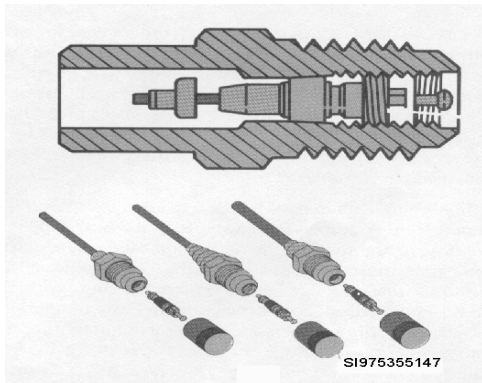


Figure 3, Schrader Valve for pressure only

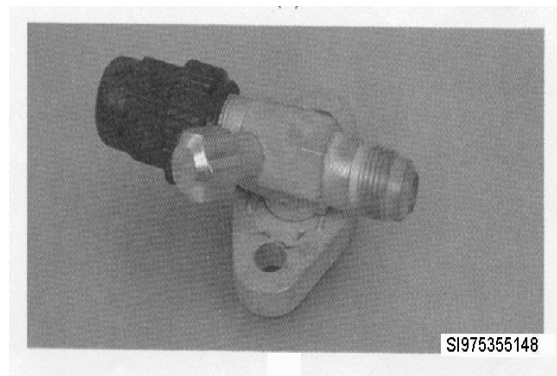


Figure 4, Service Valve

When to connect the gauges. When servicing small systems, a gauge manifold should not be connected every time the system is serviced. A small amount of refrigerant escapes each time the gauge is connected. Some residential and small commercial systems have critical refrigerant charge. When the high-side line is connected, high-pressure refrigerant will condense in the gauge line. The refrigerant will escape when the gauge line is disconnected from the Schrader connector. A gauge line full of liquid refrigerant lost while checking pressures may be enough to affect the system charge. A short gauge line connector for the high side will help prevent refrigerant loss, as shown in Figure, 5. This can be used only to check pressure. You cannot use it to transfer refrigerant out of the system because it is not a manifold.

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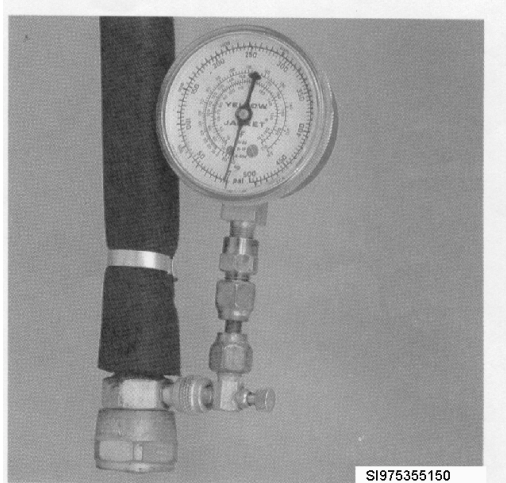


Figure 5, This short service connection is used on the high-side gauge port to keep too much refrigerant from condensing in the gauge line.

Low-side gauge readings. When using the gauge manifold on the low side of the system you can compare the actual evaporating pressure to the normal evaporating pressure. This verifies that the refrigerant is boiling at the correct temperature for the low side of the system at some load condition. It has been indicated previously that there are high-efficiency systems and standard efficiency systems and that high-efficiency systems often have oversized evaporators. This makes the suction pressure slightly higher than normal.

A standard-efficiency system usually has a refrigerant boiling temperature of about 35°F cooler than the entering air temperature at the standard operating condition of 75°F return air with a 50% humidity. If the space temperature is 85°F and the humidity is 70%, the evaporator has an oversized load. It is absorbing an extra heat load, both sensible heat and latent heat, from the moisture in the air. You need to wait a sufficient time for the system to reduce the load before you can determine if the equipment is functioning correctly. Gauge readings at this time will not reveal the kind of information that will verify the system performance unless there is a manufacturer's performance chart available.

High-side gauge readings. Gauge readings obtained on the high-pressure side of the system are used to check the relationship of the condensing refrigerant to the ambient air temperature. Standard air conditioning equipment condenses the refrigerant at no more 30°F higher than the ambient temperature. For a 95°F entering air temperature, the head pressure should correspond to $95^{\circ}\text{F} + 30^{\circ}\text{F} = 125^{\circ}\text{F}$ for a corresponding head pressure of 278 psig for R-22 and 169 psig for R-12. If the head pressure shows the condensing temperature is higher than this, something is wrong.

When checking the condenser entering air temperature, be sure to check the actual temperature. Don't take the weather report as the ambient temperature. Air conditioning equipment located on a black roof has solar influence from the air being pulled across the roof as shown in Figure 6. If the condenser is located close to any obstacles, such as below a sun deck, air may be circulated back through the condenser and causes the head pressure to be higher than normal.

High-efficiency condensers perform the same as standard-efficiency condensers except they operate at lower pressures and condensing temperatures. High-efficiency condensers normally condense the refrigerant at a temperature as low as 20°F higher than the ambient temperature. On a 95°F day the head pressure corresponds to a temperature of $95^{\circ}\text{F} + 20^{\circ}\text{F} = 115^{\circ}\text{F}$, which is a pressure of 243 psig for R-22.

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Temperature readings. Temperature readings also can be useful. The four-lead electronic thermometer performs very well as a temperature reading instrument, (Figure 8). It has small temperature leads that respond quickly to temperature changes. The leads can be attached to the refrigerant piping with tape and insulated from the ambient temperature with short pieces of foam line insulation, (Figure 7).

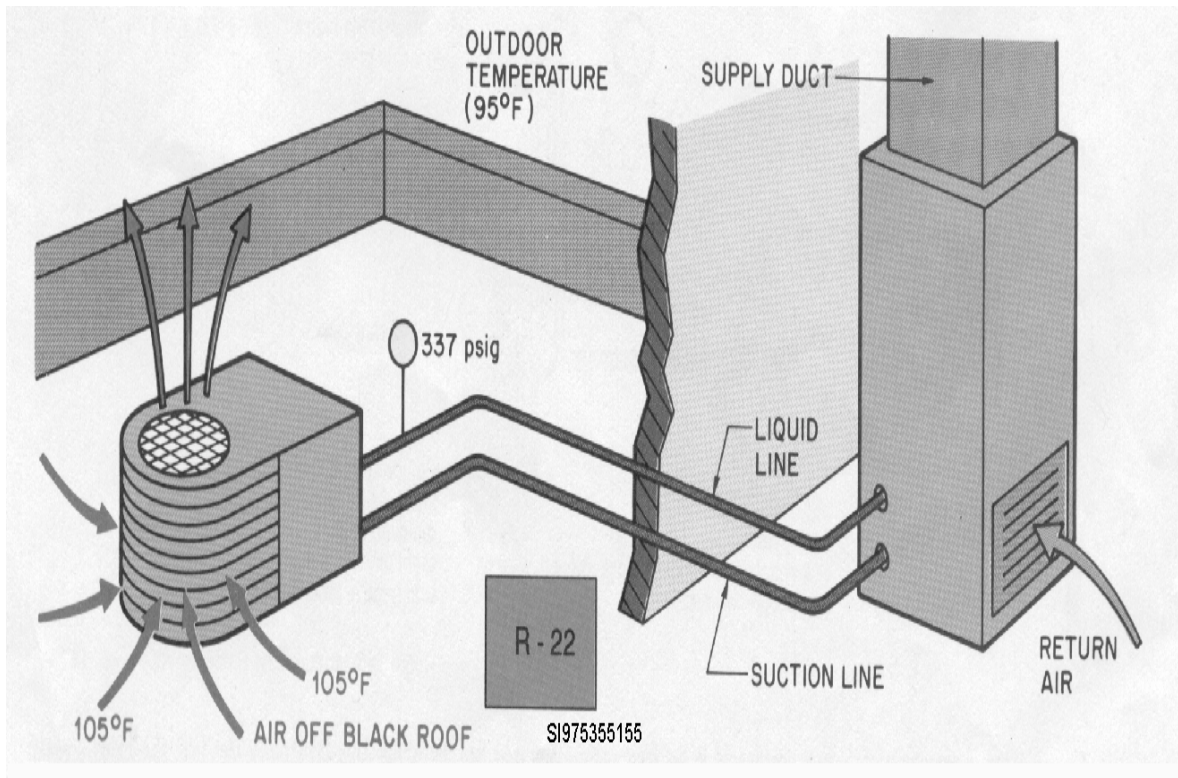


Figure 6, Condenser located low on a roof.

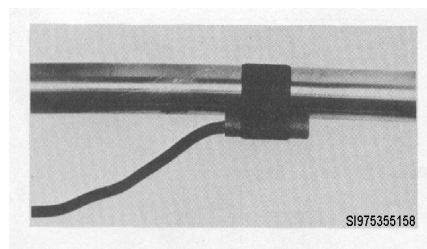


Figure 7, Temperature lead attached to a refrigerant line.

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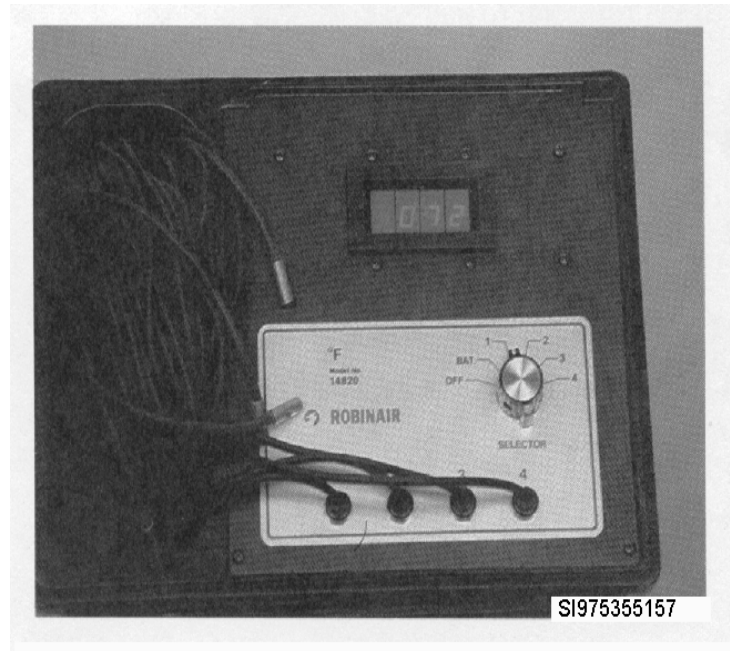


Figure 8, Four-lead thermometer.

It is important that the lead be insulated from the ambient if the ambient temperature is different from the line temperature. This temperature lead is better and easier to use than the glass thermometers used in the past. It is almost impossible to get a true line reading by strapping a glass thermometer to a copper line.

Temperatures vary from system to system. The technician must be prepared to record accurately these temperatures to evaluate the various types of equipment. Some technicians record temperature readings of various equipment under different conditions for future reference. The common temperatures used would be inlet air wet- and dry-bulb, outdoor air dry-bulb, and the suction-line temperature. Sometimes, the compressor discharge temperature needs to be known. A thermometer with a range from -50°F + 250°F is a common instrument to be used for all of the tests.

Inlet air temperatures. It may be necessary to know the inlet air temperature to the evaporator for a complete analysis of a system. A wet-bulb reading for determining the humidity may be necessary. Such a reading can be obtained by using one of the temperature leads with a cotton sock that is saturated with pure water. A wet-bulb and a dry-bulb reading may be obtained by placing a dry-bulb temperature lead next to a wet-bulb temperature lead in the return air stream. The velocity of the return air will be enough to accomplish the evaporation for the wet-bulb reading.

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Suction-line temperatures. The temperature of the suction line returning to the compressor and the suction pressure will help the technician understand the characteristics of the suction gas. The suction gas may be part liquid if the filters are stopped up or if the evaporator coil is dirty. The suction gas may have a high superheat if the unit has a low charge or if there is a refrigerant restriction. The combination of suction-line temperature and pressure will help the service technician decide whether the system has a low charge or a stopped-up air filter in the air handler. For example, if the suction pressure is too low and the suction line is warm, the system has a starved evaporator, as shown in Figure 9. If the suction-line temperature is cold and the pressure indicates that the refrigerant is boiling at a low temperature, the coil is not absorbing heat as it should. The coil may be dirty, or the airflow may be insufficient. The cold suction line indicates that the unit has enough charge because the evaporator must be full for the refrigerant to get back to the suction line.

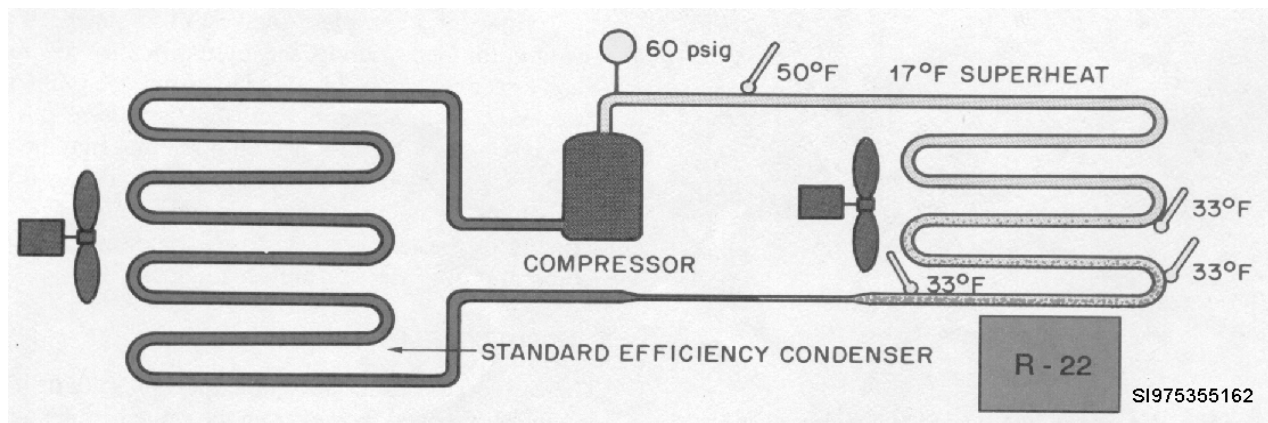


Figure 9, If the suction pressure is too low, and the suction line is not as cool as normal, the evaporator is starved for refrigerant. The unit may be low in refrigerant charge.

Discharge-line temperatures. The temperature of the discharge line may tell the technician that something is wrong inside the compressor. If there is an internal refrigerant leak from the high-pressure side to the low-pressure side, the discharge gas temperature will go up. Normally the discharge-line temperature at the compressor would not exceed 220°F for an air conditioning application even in very hot weather. When a high discharge-line temperature is discovered, the probable cause is an internal leak. The technician can prove this by building up the head pressure as high as 300 psig and then shutting off the unit. If there is an internal leak, the pressure difference between the high and the low sides can often be heard (as a whistle) equalizing through the compressor. If the suction line at the compressor shell starts to warm up immediately, the heat is coming from the discharge of the compressor.

SAFETY:

THE DISCHARGE LINE OF A COMPRESSOR MAY BE AS HOT AS 220°F UNDER NORMAL CONDITIONS, SO BE CAREFUL WHILE ATTACHING A TEMPERATURE LEAD TO THIS LINE.

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Liquid-line temperature. Liquid-line temperature may be used to check the subcooling efficiency of condenser. Most condensers will subcool the refrigerant to between 10°F and 20°F below the condensing temperature of the refrigerant. If the condensing temperature is 125°F on a 95°F day, the liquid line leaving the condenser may be 105°F to 115°F when the system is operating normally. If there is a slight low charge, there might not be as much subcooling and the system efficiency therefore will not be as good. The condenser performs three functions: (1) removes the superheat from the discharge gas, (2) condenses the refrigerant to a liquid, and (3) subcools the liquid refrigerant below the condensing temperature. All three of these functions must be successfully accomplished for the condenser to operate at its rated capacity. It's a good idea for a new technician to take the time to completely check out a working system operating at the correct pressures. Apply the temperature probes and gauges to all points to actually verify the readings. This will provide reference points to remember.

A field charging procedure may be used to check the charge of some typical systems. The technician sometimes needs typical reference points to add small amounts of gas for adjusting the amount of refrigerant in equipment that has no charging directions.

Often the technician arrives and finds the system charge needs adjusting. This can occur due to an over- or undercharge from the factory or from a previous technician's work. It can also occur from system leaks. System leaks should always be repaired to prevent further loss of charge to the atmosphere. The technician must establish charging procedures to use in the field for all types of equipment. These procedures will help get the system back on line under emergency situations. Following are some methods used for different types of equipment.

Fixed-bore metering devices: Capillary tube and orifice type. Fixed-bore metering devices like the capillary tube, do not throttle the refrigerant as the thermostatic expansion valve (TXV) does. They allow refrigerant flow based on the difference in the inlet and the outlet pressures. The one time when the system can be checked for the correct charge and everything will read normal is at the typical operating condition of 75°F and 50% humidity return air and 95°F outside ambient air. If other conditions exist, different pressures and different superheat readings will occur. The item that affects the readings the most is the outside ambient temperature. When it is lower than normal, the condenser will become more efficient and will condense the refrigerant sooner in the coil. This will have the effect of partially starving the evaporator for refrigerant. Refrigerant that is in the condenser that should be in the evaporator starves the evaporator.

When you need to check the system for correct charge or to add refrigerant, the best method is to follow the manufacturer's instructions. If they are not available, reducing the airflow across the condenser to cause the head pressure to rise may simulate the typical operating condition. On a 95°F day the highest condenser head pressure is usually 278 psig for R-22 (95°F ambient + 30°F added condensing temperature difference = 125°F condensing temperature or 278 psig). Because the high pressure pushes the refrigerant through the metering device, when the head pressure is up to the high normal end of the operating conditions there is no refrigerant held back in the condenser.

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When the condenser is pushing the refrigerant through the metering device at the correct rate, the remainder of the charge must be in the evaporator. A superheat check at the evaporator is not always easy with a split air conditioning system, so a superheat check at the condensing unit for a split system can be made. The suction line from the evaporator is not always easy with a split air conditioning system, so a superheat check at the condensing unit for a split system can be made. The suction line from the evaporator so the condensing unit may be long or short. Let's use two different lengths: up to 30 ft and from 30 to 50 ft for a test comparison. When the system is correctly charged, the superheat should be 10°F to 15°F at the condensing unit with a line length of 10 to 30 ft. The superheat should be 15°F to 18°F when the line is 30 to 50 ft long. Both of these conditions are with a head pressure of 278 psig +/- 10 psig. At these conditions the actual superheat at the evaporator will be close to the correct superheat of 10°F. When using this method, be sure that you allow enough time for the system to settle down after adding refrigerant, before you draw any conclusions. Orifice-type metering devices have a tendency to hunt while reaching steady-state operation. This hunting can be observed by watching the suction pressure rise and fall accompanied by the superheat as the suction-line temperature changes. When this occurs, the technician will have to use averaging to arrive at the proper superheat for the coil. For example, if it is varying between 6°F and 14°F, the average value of 10°F superheat may be used.

Field charging the Thermostatic Expansion Valve (TXV) system. The TXV system can be charged in much the same way as the fixed-bore system, with some modifications. The condenser on a TXV system will also hold refrigerant back in mild ambient conditions. This system always has a refrigerant reservoir or receiver to store refrigerant and will not be affected as much as the capillary tube by lower ambient conditions. To check the charge, restrict the airflow across the condenser until the head pressure simulates a 95°F ambient, 278 psig head pressure for R-22. Using the superheat method will not work for this valve because if there is an overcharge, the superheat will remain the same. Superheats of 15°F to 18°F are not unusual when measured at the condensing unit for TXVs. If the sight glass is full, the unit has at least enough refrigerant but it may have an overcharge. If the unit does not have a sight glass, a measure of the subcooling of the condenser may tell you what you want to know. For example, a typical subcooling circuit will subcool the liquid refrigerant from 10°F to 20°F cooler than the condensing temperature. A temperature lead attached to the liquid line should read 115°F to 105°F, or 10°F to 20°F cooler than the condensing temperature of 130°F. If the subcooling temperature is 20°F to 25°F cooler than the condensing temperature, the unit has an overcharge of refrigerant and the bottom of the condenser is acting as a large subcooling surface.

The charging procedures just described will also work for high-efficiency equipment. The head pressure does not need to be operated quite as high. A head pressure of 250 psig will be sufficient for an R-22 system when charging.

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Electrical troubleshooting. Electrical troubleshooting is often required at the same time as mechanical troubleshooting. The volt-ohm-ammeter (VOM) and the clamp-on ammeter are the primary instruments used, (Figure 10). You need to know what the readings should be to know whether the existing readings on a particular unit are correct. This is often not easy to determine because the desired reading may not be furnished.

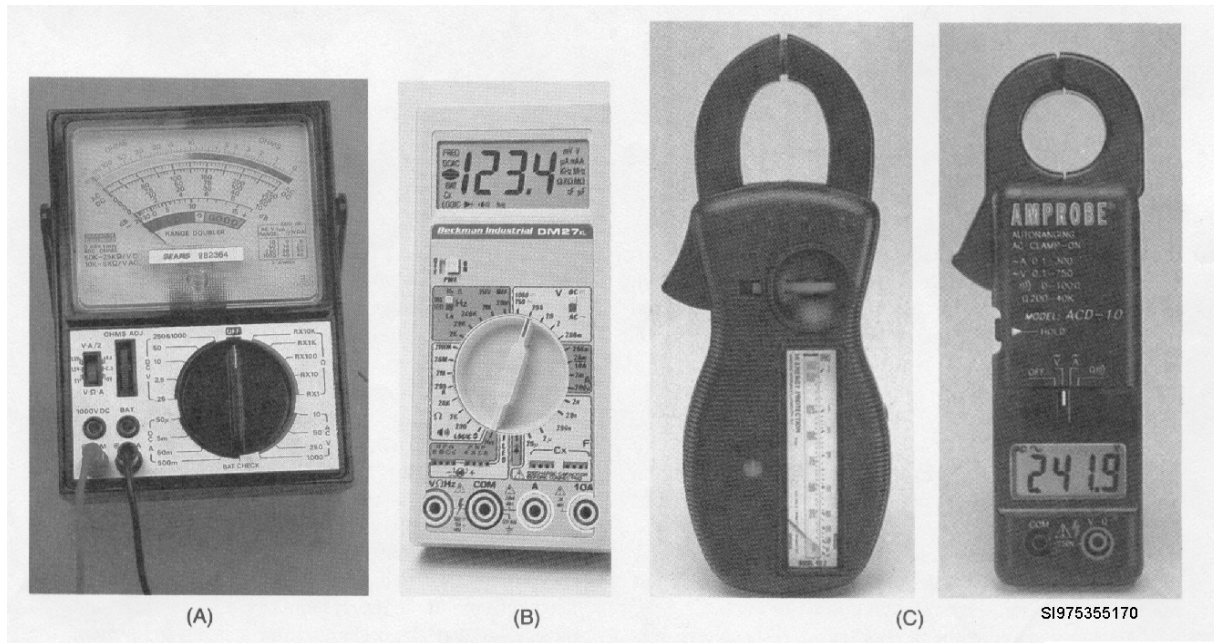


Figure 10, Instruments used to troubleshoot the electrical part of an air conditioning system. (A) Analog VOM. (B) Digital VOM. (C) Clamp-on ammeter.

For a residence or small commercial building one main power panel will normally serve the building. This panel is divided into many circuits. For a split-system type of cooling system there are usually separate breakers (or fuses) in the main panel for the air handler or furnace for the indoor unit and for the outdoor unit. For a package or self-contained system, usually one breaker (or fuse) serves the unit. The power supply voltage is stepped down by the control transformer to the control voltage of 24-V.

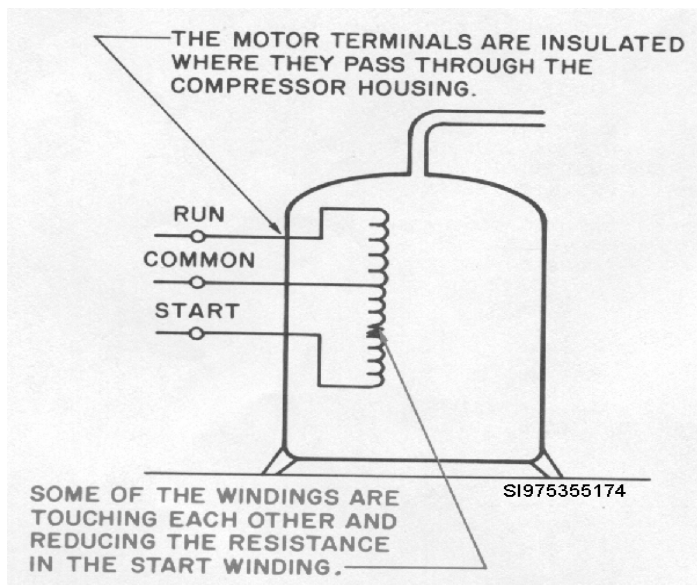
Begin any electrical troubleshooting by verifying that the power supply is energized and that the voltage is correct. If the power supply voltages are correct, move on to the various components. The path to the load may be the next item to check. If you're trying to get the compressor to run, remember that the compressor motor is operated by the compressor contactor. Is the contactor energized? Are the contacts closed?

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SAFETY:

ALL SAFETY PRACTICES MUST BE OBSERVED WHILE TROUBLESHOOTING ELECTRICAL SYSTEMS. MANY TIMES THE SYSTEM MUST BE INSPECTED WHILE POWER IS ON. ONLY LET THE INSULATED METER LEADS TOUCH THE HOT TERMINALS. SPECIAL CARE SHOULD BE TAKEN WHILE TROUBLESHOOTING THE MAIN POWER SUPPLY BECAUSE THE FUSES MAY BE CORRECTLY SIZED LARGE ENOUGH TO ALLOW GREAT AMOUNTS OF CURRENT TO FLOW BEFORE THEY BLOW (EG, WHEN A SCREWDRIVER SLIPS IN THE PANEL AND SHORTS ACROSS HOT TERMINALS). NEVER USE A SCREWDRIVER IN A HOT PANEL.

Compressor electrical checkup. You may need to perform an electrical check of the compressor if the compressor will not start or if a circuit protector has opened. For example, suppose that the compressor can be heard trying to start. It will make a humming noise but will not turn. Check the compressor with an ohmmeter to see if all of the windings are correct.



Remember that a load has to be present before current flow. The load must have the correct resistance. Let's say a compressor specification calls for the run winding to have a resistance of 4Ω and the start winding a resistance of 15Ω . If the ohmmeter indicates that the start winding has only 10Ω , then the winding has a short circuit (sometimes called a shunt). This will change the winding characteristics, and the compressor will not start. It is defective and must be changed, as shown in Figure 11. It is important to have quality instruments for making these checks.

Figure 11, Compressor with shorted winding.

The ohmmeter check may show the compressor to have an open circuit in the start or run windings. Suppose that the same symptom of a hot compressor is discovered. The compressor is allowed to cool and it still will not start. An ohm check shows that the start or run winding is open. This compressor is also defective and must be changed. When the continuity check indicates that the common circuit in the compressor is open, it could be that the internal overload protector is open because the motor may not have cooled enough. The motor is suspended in a vapor space inside the shell, and it takes time to cool.

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SAFETY:

NEVER USE AN OHMMETER TO CHECK A LIVE CIRCUIT.

Troubleshooting the circuit electrical protectors—fuses and breakers. One service call that must be treated cautiously is when a circuit protector such as a fuse or breaker opens the circuit. The compressor and fan motors have protection that will normally guard them from minor problems. The breaker or fuse is for large current surges in the circuit. When one is tripped, don't simply reset it. Perform a resistance check of the compressor section, including the fan motor. *The compressor might be grounded (has a circuit to the case of the compressor), and it will be harmful to try to start it. * **Be sure to isolate the compressor circuit before condemning the compressor.** Take the motor leads off the compressor to check for a ground circuit in the compressor. Many homes and businesses have air conditioning (summer cooling). These systems operate in the spring, summer, and fall for the purpose of comfort for the occupants. These systems are often connected to the heating systems. Air conditioning may also be combined with any heat pump system. Always listen to the owner to help to identify the potential problem.

Diagnostic Chart for Summer Air-Conditioning Systems

PROBLEM	POSSIBLE CAUSE	POSSIBLE REPAIR
No cooling, outdoor unit not running indoor fan running	Open outdoor disconnect switch Open fuse or breaker Faulty wiring	Close disconnect switch Replace fuse, reset breaker and determine problem Repair or replace faulty wiring or connections
No cooling, indoor fan and outdoor unit will not run	Low voltage control problem A. Thermostat B. Interconnecting wiring or connections C. Transformer	Repair loose connections or replace thermostat and or sub base Repair or replace wiring or connections Replace if defective SAFETY PRECAUTION: Look out for too much current draw due to ground circuit or shorted coil

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Diagnostic Chart for Summer Air Conditioning Systems

PROBLEM	POSSIBLE CAUSE	POSSIBLE REPAIR
No cooling, indoor and outdoor fans running, but compressor not running	<p>Tripped compressor internal overload</p> <p>A. Low line voltage</p> <p>B. High head pressure</p> <ol style="list-style-type: none"> 1. Dirty outdoor (condenser) 2. Condenser fan not running all the time 3. Condenser air recirculating 4. Overcharge of refrigerant <p>C. Low charge, motor not being properly cooled</p>	<p>Correct low voltage, power company or loose connections</p> <p>Clean condenser</p> <p>Check condenser fan motor and capacitor</p> <p>Correct recirculating problem</p> <p>Correct charge</p> <p>Correct charge, if due to leak, repair leak</p>
Indoor coil freezing	<p>Restricted airflow</p> <p>Low charge</p> <p>Metering device</p> <p>Restricted filter drier</p> <p>Operating unit during low ambient conditions without head pressure control</p>	<p>Change filters</p> <p>Open all supply registers dampers</p> <p>Clear return air blockage</p> <p>Clean fan blades</p> <p>Speed fan up to higher speed</p> <p>Adjust unit charge-repair leak if refrigerant has been lost</p> <p>Change or clean metering device</p> <p>Change filter drier</p> <p>Add filter drier</p> <p>Add proper low ambient head pressure control</p>

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Troubleshooting Heat Pumps: The basic refrigeration cycle is similar to heat pumps; however, heat pumps have the ability of pumping heat either way. The four-way valve enables the heat pump to reverse the refrigeration cycle and reject heat in either way. Different names are used for the heat pump components because of the reverse-cycle operation. These include:

- **Coils.** In cooling air conditioning equipment, the coil inside the condition space is called an evaporator. On a heat pump unit is called an indoor coil. Sometimes it is operated as a condenser in winter and as an evaporator in summer. When applied to cooling air conditioning equipment, the coil outside the condition space is called a condensing unit. With a heat pump, this unit is an evaporator in winter and a condenser in summer. It is called the outdoor coil.
- **Lines.** The refrigerant lines that connect the indoor and outdoor coil are the gas lines and the liquid line. The liquid line is always the liquid line; the flow reverses from season to season. The gas line, hot gas in winter and cold gas in summer.
- **Metering devices.** Different metering devices are used with heat pumps. One is the TXV. There must be two of them, with a check valve installed in parallel to the valve to force the liquid refrigerant to flow through the valve. Capillary tube metering devices are common. There must be two of them, one for cooling and one for heating operations. They must have a check valve installed in parallel to force the liquid refrigerant to flow correctly. Also, a fixed-bore metering device that will allow full flow in one direction and restricted flow in the other direction is used by many manufactures. The electronic expansion valve is used by some manufactures with close-coupled equipment because it will meter in both direction and maintain the correct superheat.

Auxiliary heat. When the outdoor temperature gets colder, the conditioned space needs more heat and the heat pump provides less. At a point the heat pump alone will run constantly and just heat the conditioned space. If the outdoor temperature drops lower, the heat pump needs help. Auxiliary heat is normally what a heat pump uses as a supplement.

Auxiliary heat is normally electric resistance heat. When the auxiliary heat is used as the only heat source, such as when the heat pump fails, it is called emergency heat. Emergency heat is controlled with a switch on the room thermostat. This switch turns off the heat pump and turns on the auxiliary heat.

Typical high-pressure conditions. Typical high-side pressure operating conditions can either be applied to air-cooled equipment or water-cooled equipment. Troubleshooting is very different for each.

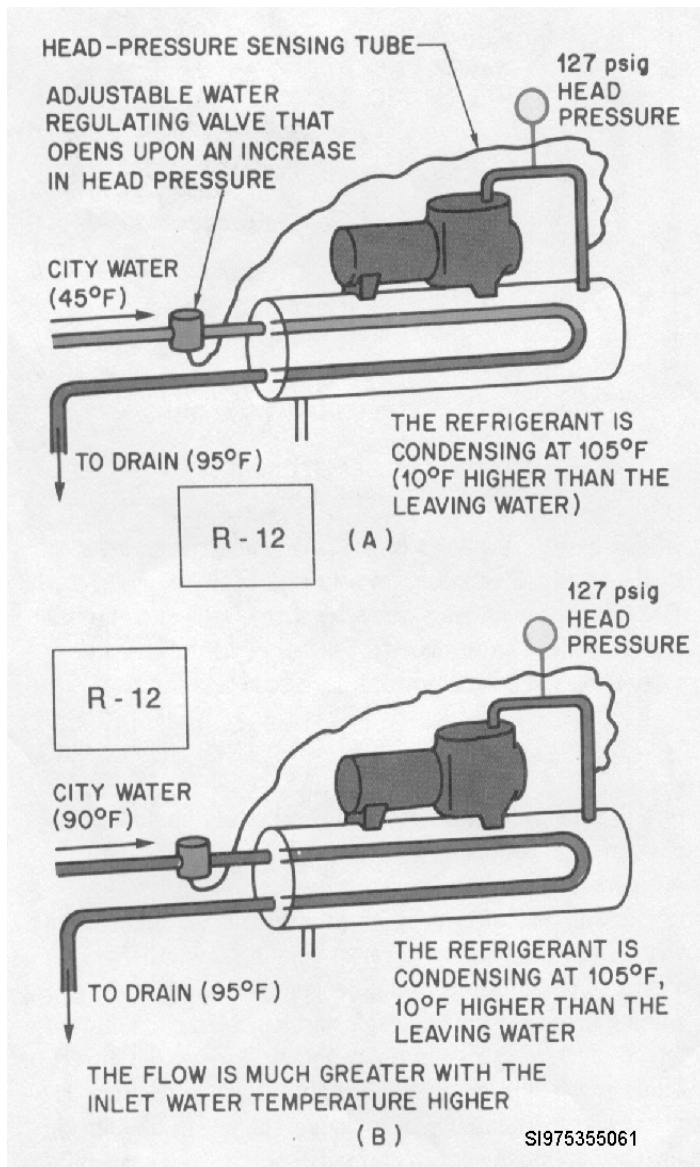
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Typical air-cooled condenser operating conditions. Air-cooled condensers have an operating temperature range from cold to hot as they are exposed to outside temperatures. The equipment may even be located inside a conditioned building. The condenser has to maintain a pressure that will create enough pressure drop across the expansion device for it to feed correctly. This pressure drop across the expansion device will push enough refrigerant through the device for proper evaporator refrigerant levels in the evaporator.

Calculating the correct head pressure for air-cooled equipment. The maximum normal high-side pressure would correspond to the maximum ambient temperature in which the condenser is operated. Most air-cooled condensers will condense the refrigerant at a temperature of about 30°F above the ambient temperature when the ambient is above 70°F. When the ambient temperature drops below 70°F, the relationship changes to a lower value. If the condenser is a higher-efficiency condenser or oversized, the condenser may condense at 25°F above the ambient. Using the 30°F, we see that if a unit were located outside and the temperature were 95°F, the condensing temperature would be $95^{\circ}\text{F} + 30^{\circ}\text{F} = 125^{\circ}\text{F}$. This corresponds to a gauge pressure of 278 psig for R-22 and 185 psig for R-134A.

Typical operating conditions for water-cooled equipment. Water-cooled condensers are used in many systems in two ways. Some are wastewater, and some reuse the same water by extracting the heat with a cooling tower. Typically a water-cooled condenser that uses fresh water, such as city water or well water, uses about 1.5 gal of water per minute per ton while a system using a cooling tower circulates about 3 gal/ton. These two applications have different operating conditions and will be discussed separately.

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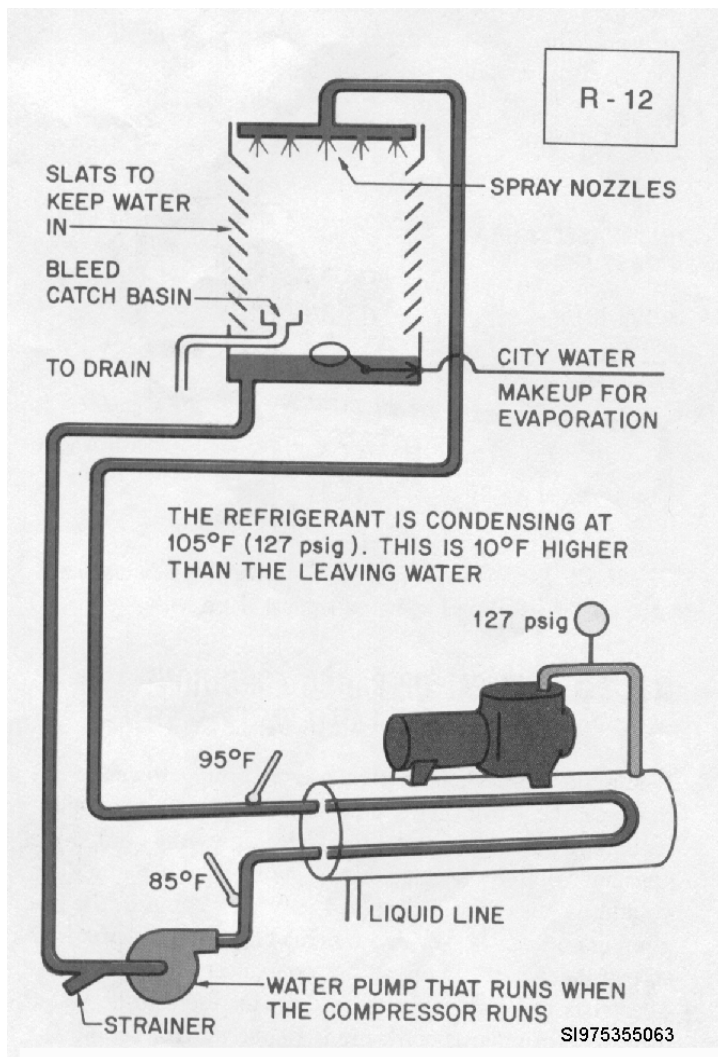
Typical operating conditions for wastewater condenser systems.

Wastewater systems use the same condensers as the cooling tower applications, but the water is wasted down the drain. Normally a water-regulating valve is used to regulate the water flow for economy and to regulate the head pressure (See Figure 12). When a water-regulating valve is used to control the water flow, the water flow will be greater if the condenser is not performing correctly.

When the head pressure goes up, the water will start to flow faster to compensate. This will take place until the capacity of the valve opening is reached. Then the head pressure will increase with maximum water flow. The head pressure has a more consistent relationship with the outlet water temperature because the outlet water temperature is more of a constant than the inlet water. Sometimes the inlet water is colder, such as in winter. It would not be unusual for the inlet water to be 45°F in the winter. 90°F may be the high value if the water travels through a hot ceiling in the summer.

Figure 12, Water-cooled wastewater air-conditioning system

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Typical operating conditions for recirculated water systems.

Water-cooled condensers that use a cooling tower to remove the heat from the water normally do not use water-regulating valves to control the water flow. It is normally a constant volume of water that is pumped by a pump. The volume is customarily designed into the system in the beginning and can be verified by checking the pressure drop across the water circuit at the condenser inlet to outlet. There has to be some pressure drop for there to be water flow.

The original specifications of the system should include the engineer's intent with regard to the water flow, but these may not be obtainable on an old installation. Most systems that reuse the same water with a cooling tower have a standard 10°F temperature rise across the condenser. For example, if the water from the tower were to be 85°F entering the condenser, the water leaving the condenser should be 95°F.

Figure 13, Typical water-cooled air-conditioning system

Figure 13, shows a water-cooled air-conditioning system reusing the water after the heat is rejected to the atmosphere. There is a constant bleed of water to keep the system from over concentrating with the minerals left behind when the water is evaporated. The difference in the incoming water and the leaving water is 10°F. This is the typical temperature rise across a water tower system. If the difference were to be 15°F or 20°F, you might think that the condenser is doing its job of removing the heat from the refrigerant, but the water flow is insufficient. If the water temperature entering the condenser were to be 85 and the leaving water were to be 90°F, it may be that there is too much water flow. If the head pressure is not high, the condenser is removing the heat, and there is too much water flow. If the head pressure is high and there is the right amount of water flow, the condenser is dirty.

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The condenser has a relationship of heat exchange with the condenser water like the wastewater system. The refrigerant normally condenses about 10°F warmer than the leaving water. If the leaving water is 95°F, a properly operating condenser should be condensing at 105°F, resulting in a pressure of 135 psig for R-134A and 211 psig for R-22.

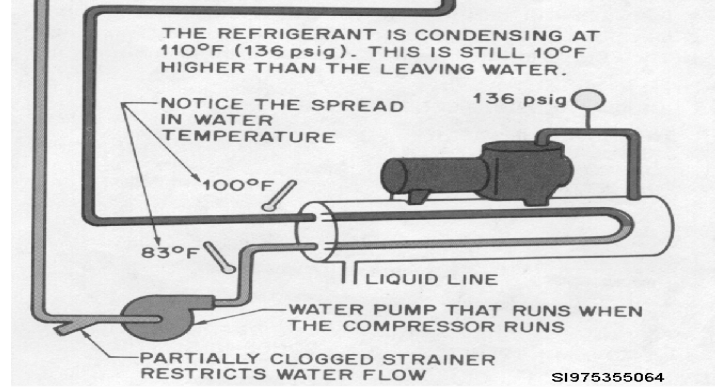


Figure 14, This system has too much temperature rise.

(where a fan forces the air through the tower). Either tower will be able to supply water temperature according to the humidity or moisture content in the outside air. The cooling tower can normally cool the water to within 7°F of the wet-bulb temperature of the outside air. If the outside wet-bulb temperature (taken with a psychrometer) is 78°F, the leaving water will be about 85°F if the tower is performing correctly. Figure 14, shows a system that has too much temperature rise indicating there is not enough water flow. The water strainers may be stopped up. The condensing temperature is higher than normal, which causes the head pressure to rise. A decrease in water flow may be detected by water pressure drop if it is known what it is supposed to be.

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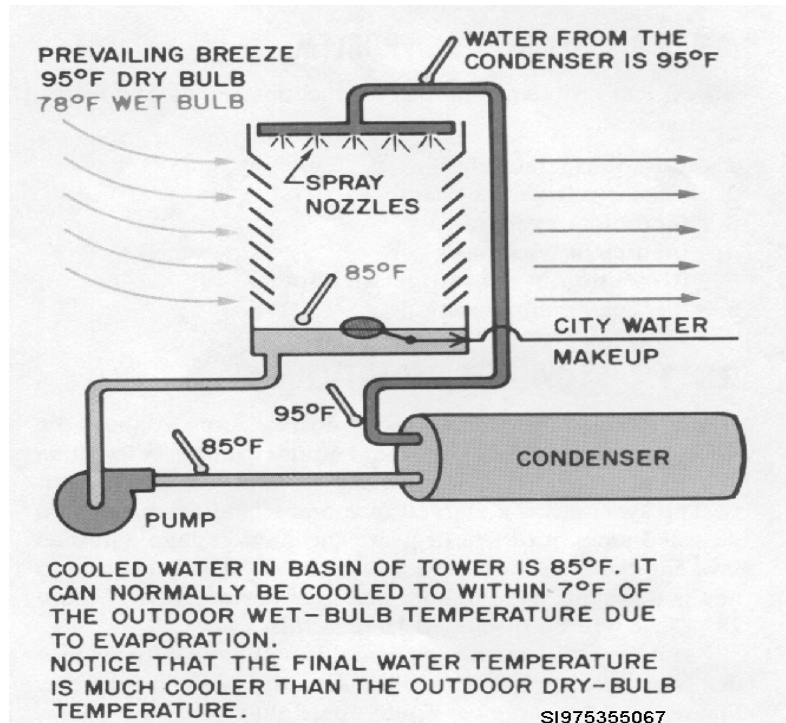


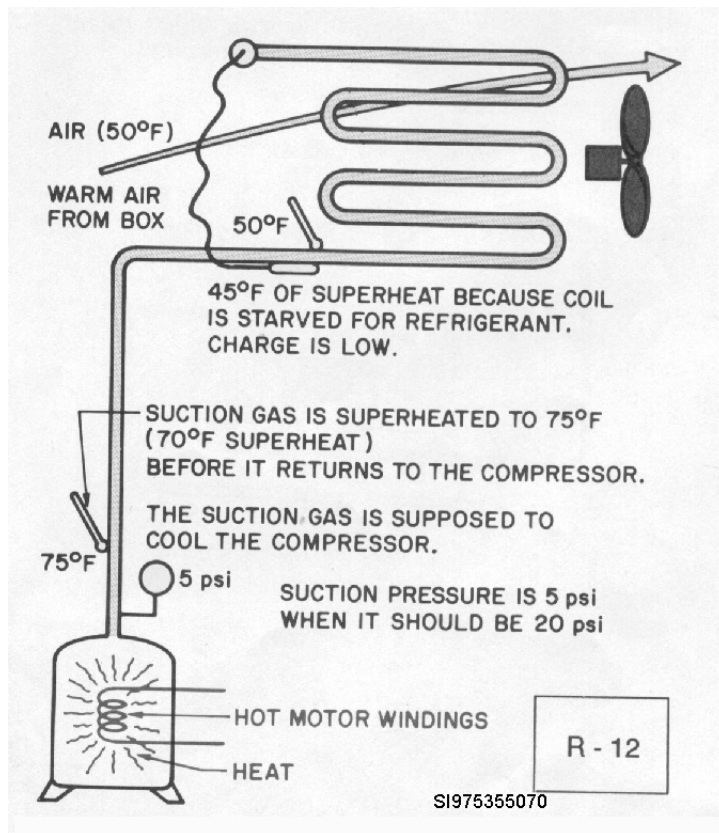
Figure 15, Typical Cooling tower temperature relationship

A Cooling tower has a temperature relationship with the air that is cooling the water, which is shown in Figure 15. Most cooling towers can cool the water that goes back to the condenser to within 7°F of the wet-bulb temperature of the ambient air. For example, if the wet-bulb temperature is 78°F, the tower should be able to cool the water to 85°F. If it does not, a tower problem should be suspected

Six Typical Problems. Six typical problems that can be encountered by any air-conditioning system are:

1. Low refrigerant charge
2. Excess refrigerant charge
3. Inefficient evaporator
4. Inefficient condenser
5. Restriction in the refrigerant circuit
6. Inefficient compressor

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Low refrigerant charge. A low refrigerant charge affects most systems in about the same way, depending on the amount of the refrigerant needed to be correct. The normal symptoms are low capacity. The system has a starved evaporator and cannot absorb the rated amount of BTU or heat. The suction gauge will read low, and the discharged gauge will read low. The exception to this is a system with an automatic expansion valve. It will be discussed later in this unit.

If the system has a sight glass, it will have bubbles in it that look like air but which are actually vapor refrigerants. Remember that a sight glass that is full of vapor or liquid may look the same. If there is only vapor in the glass, a slight film of oil may be present. This is a good indicator of vapor only.

Figure 16, System with a suction-cooled hermetic compressor.

When a system has a sight glass, it will generally have a thermostatic expansion valve (TXV) or automatic expansion valve and a receiver. These valves will hiss when a partial vapor-partial liquid mixture is going through the valve. The technician needs to know how the system feels to the touch at different points to determine the gas charge level without using gauges. The low charge affects the compressor by not supplying the cool suction vapor to the motor. Most compressors are suction cooled, so the result is a hot compressor motor. It may even be off due to the motor-winding thermostat, as shown in Figure 16.

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Refrigerant overcharge. A refrigerant overcharge also acts much the same way from system to system. The discharge pressure is high, and the suction pressure may be high. The automatic expansion valve system will not have a high suction pressure because it maintains a constant suction pressure. The TXV may have a slightly higher suction pressure if the head pressure is excessively high because the system capacity may be down.

The capillary tube will have a high suction pressure because the amount of refrigerant flowing through it depends on the difference in pressure across it. The more head pressure, the more liquid it will pass. The capillary tube will allow enough refrigerant to pass so that it will allow liquid into the compressor. When the compressor is sweating down the side or all over, it is a sign of liquid refrigerant in the compressor. The compressor should only have vapor entering it. Vapor will rise in temperature as soon as it touches the compressor shell. When liquid is present, it will not rise in temperature and will cool the compressor shell.

NOTE:

Liquid refrigerant still has its latent heat absorption capability and will absorb a great amount of heat without changing temperature. A vapor absorbs only sensible heat and will change in temperature quickly.

Another reason that liquid may get back to the compressor is poor heat exchange in the evaporator in a capillary tube system. If liquid is getting back to the compressor the evaporator heat exchange should be checked before removing refrigerant.

Inefficient evaporator. An inefficient evaporator does not absorb the heat into the system and will have a low suction pressure. The suction line may be sweating or frosting back to the compressor. An inefficient evaporator can be caused by a dirty coil, a fan running too slowly, and expansion valve starving the coil, recirculated air, ice buildup, or dirty air filters. All of these can be checked with an evaporator performance check. This check can be performed by making sure that the evaporator has the correct amount of refrigerant with a superheat check. The heat exchange surface should be clean. The fans should be blowing enough air and not recirculating it from the discharge to the inlet of the coil. The refrigerant boiling temperature should not be more than 20°F colder than the entering air on an air evaporator coil. A water coil should have no more than a 10°F TD in the boiling refrigerant and the leaving water. When the boiling refrigerant relationship to the medium being cooled starts increasing, the heat exchange is decreasing.

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Inefficient condenser. An inefficient condenser acts the same whether it is water-cooled or air-cooled. If the condenser cannot remove the heat from the refrigerant, the head pressure will go up. The condenser does three things and has to be able to do them correctly, or excessive pressures will occur.

- De-superheat the hot gas from the compressor. This gas may be 200°F or hotter on a hot day on air-cooled system. De-superheating is accomplished in the beginning of the coil.
- Condense the refrigerant. This is done in the middle of the coil. The middle of the coil where the condensing is occurring is the only place that the coil temperature will correspond to the head pressure. You could check the temperature against the head pressure if a correct temperature reading can be taken, but the fins are usually in the way.
- Subcool the refrigerant before it leaves the coil. This subcooling is cooling the refrigerant to a point below the actual condensing temperature. A subcooling of 5°F to 20°F is typical. The subcooling can be checked just like the superheat; only the temperature is checked at the liquid line and compared to the high-side pressure converted to condensing temperature.

The condenser does three jobs as shown in Figure 17: (1) de-superheats the hot gas, in the first part of the condenser. (2) Condenses the vapor refrigerant to a liquid, in the middle of the condenser. (3) Subcools the refrigerant at the end of the condenser. The condensing temperature corresponds to the head pressure. Subcooling is the temperature of the liquid line subtracted from the condensing temperature. A typical condenser can subcool the liquid refrigerant 5°F to 20°F cooler than the condensing temperature.

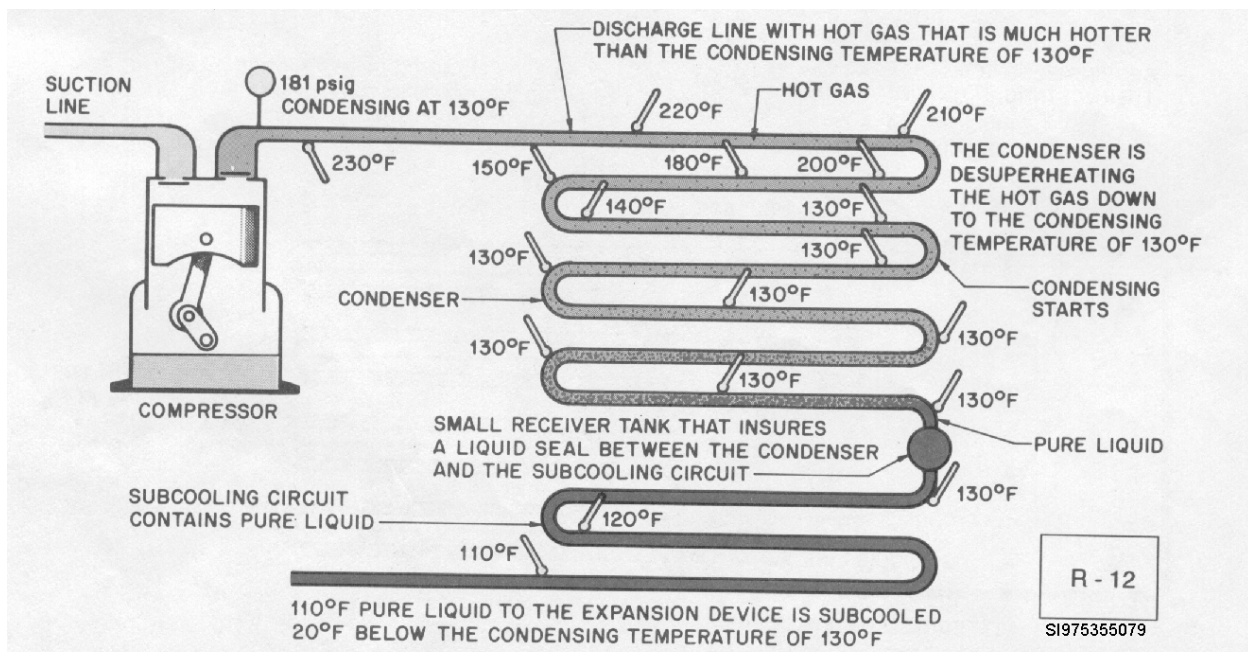


Figure 17, Checking the subcooling on a condenser.

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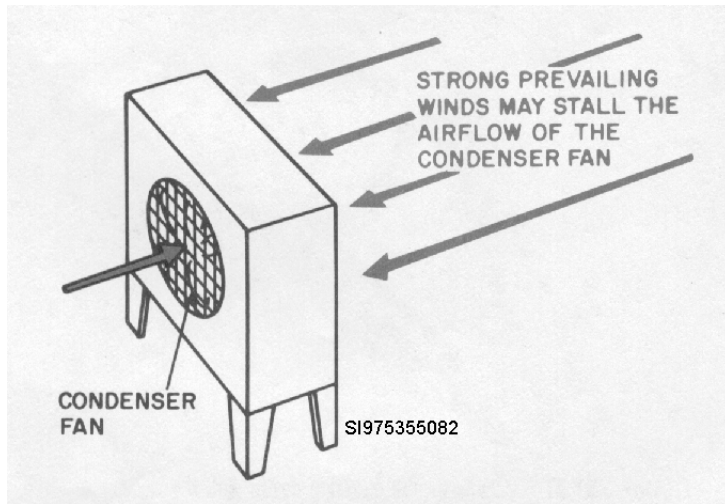


Figure 18, A condenser that is located in such a manner that it is discharging its air into a strong prevailing wind may not get enough air across the coil.

The condenser must have the correct amount of cooling. An air-cooled condenser should not be located down low, close to the roof, even though the air comes in the side. The temperature is higher at the roof level than it is a few inches higher. A clearance of about 18 in. will give better condenser performance. An air-cooled condenser that has a vertical coil may be influenced by prevailing winds. If the fan is trying to discharge its air into a 20 mph wind, it may not move the correct amount of air, and a high head pressure may occur, as shown in Figure 18.

Refrigerant flow restrictions. Restrictions that occur in the air-conditioning circuit are either partial or full. A partial restriction may be in the vapor or the liquid line. A restriction always causes pressure drop at the point of the restriction. Different conditions will occur, depending on where the restriction is. Pressure drop can always be detected with gauges, but the gauges cannot always indicate the correct location of the restriction. Gauge ports may need to be installed for pressure testing.

If a restriction occurs due to something outside the system, it is usually physical damage, such as flattened or bent tubing. These can be hard to find if they are in hidden places such as under insulation or behind a fixture.

If a partial restriction occurs in a liquid, line it will be evident because the refrigerant will have a pressure drop and will start to act like an expansion device at the point of the restriction. When there is a pressure drop in a liquid line, there is always a temperature change. A temperature check on each side of a restriction will locate the place. Sometimes when the drop is across a drier, the temperature difference from one side to the other may not be enough to feel with bare hands, but a thermometer will detect it, as seen in Figure 19.

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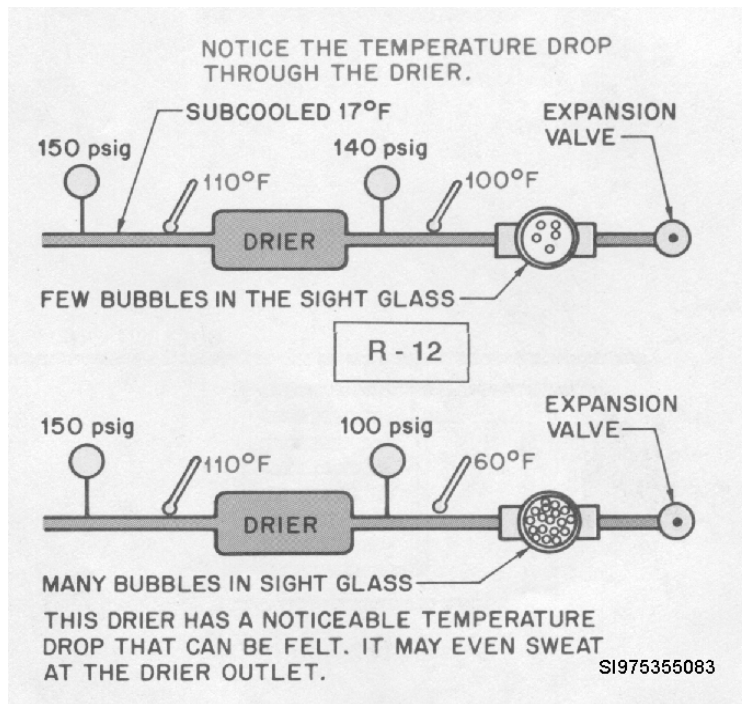


Figure 19, The driers each have a restriction.

it can be inspected and cleaned if necessary. If it is a capillary tube, it will be soldered into the line and not easy to inspect.

Water circulating in any system that operates below freezing will freeze at the first cold place it passes through. This would be in the expansion device. One drop of water can stop a air-conditioning system. Sometimes a piece of equipment that has just been serviced will show signs of moisture on the first hot day. This is because the drier in the liquid line will have more capacity to hold moisture when it is cool. The first hot day, the drier may turn a drop or two of water loose and it will freeze in the expansion device. When you suspect this, apply heat to thaw the water to a liquid. Care must be used when applying heat. A hot wet cloth is a good source. If applying a hot cloth to the metering device causes the system to start functioning properly, the problem is free water in the system. Recover the refrigerant, change the drier, and evacuate the system.

Inefficient compressor. Inefficient compressor operation can be one of the most difficult problems to find. When a compressor will not run, it is evident where the problem is. Motor troubleshooting procedures are covered in a separate unit. When a compressor is pumping at slightly less than capacity, it is hard to determine the problem. It helps at this point to remember that a compressor is a vapor pump. It should be able to create a pressure from the low side of the system to the high side under design conditions.

If a system has been running for a long time and a restriction occurs, physical damage may have occurred. If the restriction occurs soon after start a filter or drier may be stopping up. When this occurs in the liquid line drier, bubbles will appear in the sight glass when the drier is located before the sight glass.

Another occurrence that may create a partial restriction could be valves that do not open all the way. Normally the TXV either works or it doesn't. It will function correctly, but if it loses its charge in the thermal bulb, it will close and cause a full restriction.

There is a strainer at the inlet to most expansion devices that can trap particles and stop up slowly. If the device is a valve that can be removed,

Service technicians use all the following methods to discover compressor problems:

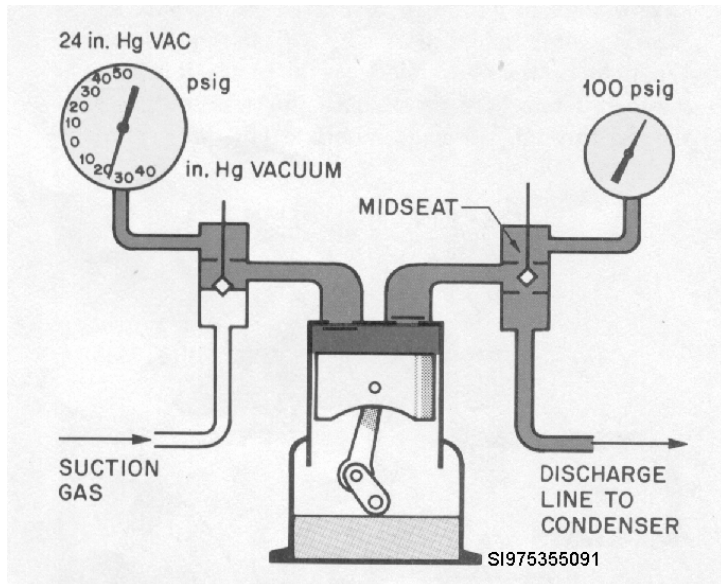


Figure 20, Compressor check by pulling a vacuum while pumping against a head.

Compressor vacuum test. Care must be taken not to pull air into the system while in a vacuum. All reciprocating compressors should immediately go into a vacuum if the suction line is valved off when the compressor is running. This test proves that the suction valves are seating correctly on at least one cylinder. This test is not satisfactory on a multi-cylinder compressor. If one cylinder will pump correctly, a vacuum will be pulled. A reciprocating compressor should pull 26 in. Hg vacuum with the atmosphere as the discharge pressure.

discharge pressure, as shown in Figure 20. When the compressor has pumped a differential pressure and is stopped, the pressures should not equalize. For example, a compressor has been operated until the suction pressure is 24 in. Hg vacuum and the head pressure is 100 psig, then it is stopped. These pressures should stay the same while the compressor is off. When refrigerant is used for this pumping test, the 100 psig will drop some because of the condensing refrigerant. Most compressor motors are cooled with suction gas and will get hot if operated for any length of time performing these tests. This vacuum test should not take more than 3 to 5 min. The motor will not overheat in this period of time. ***The test should only be performed by experienced technicians.**

The compressor should pull about 24 in Hg vacuum, against 100-psig

Compressor running test in the system. Running test in the system can be performed by creating typical design conditions in the system. *Typically, a compressor will operate at a high suction and a low head pressure when it is not pumping to capacity. This will cause the compressor to operate at a low current.* When the technician gets to the job, the conditions are not usually at the design level. The fixture is usually not cooling correctly—this is what instigated the call to begin with. The technician may not be able to create design conditions, but the following approach should be tried if the compressor capacity is suspected.

To perform this task, follow these steps:

Step 1: Install the high- and low-side gauges.

Step 2: Make sure that the charge is correct using manufactures recommendations.

Step 3: Check the compressor current and compare to full load.

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Step 4: Block the condenser airflow and build up the head pressure.

If the compressor will not pump the head pressure up to the equivalent of a 95°F (95°F + 30°F = 125°F condensing temperature or 185 psig for R-134A and 278 psig for R-22) day and draw close to the nameplate full-load current, the compressor is not pumping.

NOTE:

When making a service call to a business, never park your truck or van in a space reserved for customers. Look professional and be professional. Before starting troubleshooting procedures, get all the information you can regard the problem. Be extremely careful not to scratch tile floors or to soil carpeting with your tools or by moving equipment. Be sure to practice good sanitary and hygiene habits when working in a food preparation area. Keep your tools and equipment out of the customers' and employees' way if the equipment you are servicing is located in a normal traffic pattern. Be prepared with the correct tools and ensure they are in good condition. Always clean up after you have finished. Try to provide a little extra service by cleaning filters, oiling motors or by providing some other service that will impress the customer. Always discuss the results of your service call with the owner or representative of the company. Try to persuade the owner to call if there are any questions as a result of the service call.

Review Questions for Troubleshoot

Correct Malfunctions

Question	Answer
1. Inexperienced persons should perform troubleshooting tasks only under the supervision of an experienced person.	a. True b. False
2. If an evaporator fan motor capacitor fails, the motor will speed up and begin to get hot.	a. True b. False
3. Starting in 1992, the common refrigerant for automobile air conditioning is R-134a.	a. True b. False
4. The _____ displays the low- and high-side pressures while the unit is operating.	a. Manifold gauge b. Amp gauge c. Ohmmeter d. Manifold meter
5. There are two types of pressure connections used with air conditioning equipment. They are the _____ and _____.	a. Schrader valve and the service valve b. Schroeder valve and the coolant c. Schafer valve and pressure valve d. Schad valve and water valve
6. On a 95°F day the head pressure corresponds to a temperature of 95°F + 20°F = 115°F, which is a pressure of 243 psig for R-22.	a. True b. False
7. A thermometer with a range from -50°F + 250°F is a common instrument to be used for all of the tests.	a. True b. False

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TROUBLESHOOT
CORRECT MALFUNCTIONS

Performance Checklist		
Step	Yes	No
1. Did trainee troubleshoot and repair mechanical/electrical problems in an AC system?		
a. Step 1 - Talk to customer- understand problem?		
b. Step 2 - Check power-correct as necessary?		
c. Step 3 - Check evaporator air flow- correct as necessary?		
d. Step 4 - Check condenser air flow- correct as necessary?		
e. Step 5 - Check compressor operation- correct as necessary?		

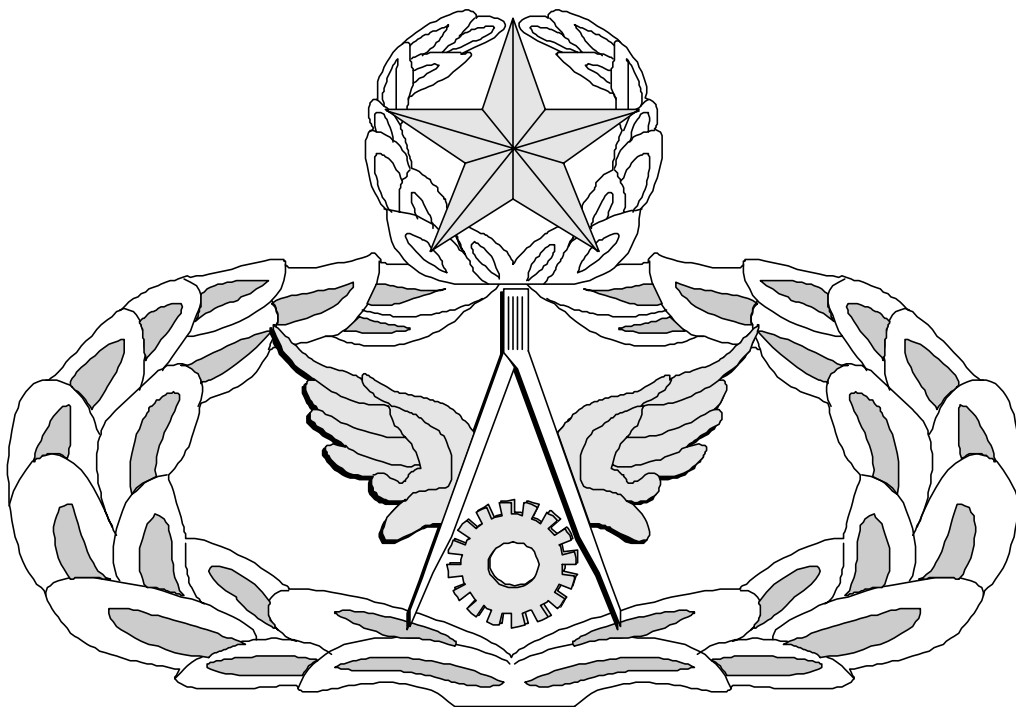
FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

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Air Force Civil Engineer

QUALIFICATION TRAINING PACKAGE (QTP)

REVIEW ANSWER KEY



For
HVAC/REFRIGERATION

(3E1X1)

MODULE 21

AIR CONDITIONING & REFRIGERATION SYSTEMS

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Key-1

LOCATE REFRIGERANT LEAKS

(3E1X1-21.3.1.)

Question	Answer
1. Refrigeration systems must be absolutely gas tight.	a. True
2. What must the service specialist check before charging a system?	d. Check to insure all leaks have been repaired
3. For any appliance containing more than _____ pounds of refrigerant, the owner must keep a record of all refrigerant charged into that appliance.	a. 50
4. Pressurizing newly installed split systems or built-up systems with HCFC or CFC refrigerants for leak checking is a standard practice.	b. False

OBTAIN UNIVERSAL CERTIFICATION

(3E1X1-21.3.2.)

Question	Answer
1. What are the four classes of certification?	d. B and C
2. What technician certification program is required and approved by a certifying organization under the mandatory program?	d. EPA

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RECOVER, RECYCLE, AND RECLAIM REFRIGERANTS FROM REFRIGERATION AND AIR CONDITIONING SYSTEMS

(3E1X1 21.3.3.)

Questions	Answers
1. Recycling refrigerant is the act of bringing the refrigerant to factory specifications.	b. False
2. The EPA is the only authority able to certify recovery equipment.	b. False
3. Very high-pressure appliances containing CFC-503 must be evacuated to what pressure.	c. 0 psi
4. In reclaim equipment how is the refrigerant introduced to the equipment?	d. As either liquid or vapor
5. If refrigerant contacts the <u>skin</u> it can cause?	c. Frostbite
6. All HVAC personnel in the Air Force will be certified as a _____.	d. Universal technician.

PUMP DOWN REFRIGERATION SYSTEM

(3E1X1-21.3.4.)

Question	Answer
1. The act of <i>using the compressor</i> to move and store the refrigerant in the receiver or condenser is defined as pump down.	a. True
2. At what pressure is the compressor stopped?	a. 1-5 PSIG
3. For any service work requiring access to the compressor or the sealed part of the system, the refrigerant must first be removed.	a. True
4. The pump down procedure is accomplished by closing the valve at the outlet of the receiver or condenser while the _____ is operating.	a. Compressor
5. If it is necessary to remove or gain access to the discharge line, condenser, or receiver, pumping the system down is of no benefit, and the refrigerant charge must be removed unless there are valves to isolate the defective component.	a. True

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PRESSURE CHECK REFRIGERATION SYSTEMS

(3E1X1-21.3.5.)

Question	Answer
1. The manifold has 3 ports to connect service hoses.	a. True
2. What pressure gauge indicates pressure both above and below atmospheric pressure?	d. Manifold gauge
3. What color is the low side gauge?	c. Blue
4. What color is the high side gauge?	a. Red

CHARGE HVAC/R SYSTEMS WITH REFRIGERANT

(3E1X1-21.3.6.)

Question	Answer
1. What is the most accurate charging procedure?	a. Weight
2. A sight glass will show bubbles if the system has _____?	d. All of the above
3. What is the proper superheat range when the system is properly charged?	d. 8-12 Degrees F
4. There are two ways of charging refrigerant systems; _____ and _____.	a. Vapor and liquid.

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TROUBLESHOOT

(3E1X1-21.5.3.12.1)

CORRECT MALFUNCTIONS

(3E1X1-21.5.3.12.2)

Question	Answer
1. Inexperienced persons should perform troubleshooting tasks only under the supervision of an experienced person.	a. True
2. If an evaporator fan motor capacitor fails, the motor will speed up and begin to get hot.	b. False
3. Starting in 1992 the common refrigerant for automobile air conditioning is R-134a.	a. True
4. The _____ displays the low- and high-side pressures while the unit is operating.	a. Manifold Gauge
5. There are two types of pressure connections used with air conditioning equipment. They are the _____ and _____.	a. Schrader valve and the service valve.
6. On a 95°F day the head pressure corresponds to a temperature of $95^{\circ}\text{F} + 20^{\circ}\text{F} = 115^{\circ}\text{F}$, which is a pressure of 243 psig for R-22.	b. False
7. A thermometer with a range from $-50^{\circ}\text{F} + 250^{\circ}\text{F}$ is a common instrument to be used for all of the test.	a. True

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